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ON THE INTERVAL BETWEEN SUCCESSIVE BIRTHS AND ITS EFFECT ON SURVIVAL OF INFANT*

I. AN INDIRECT METHOD OF STUDY

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THE physiological changes which occur in the female during pregnancy and parturition are more intense than those which take place during any other normal period of life. The time interval between the termination of one pregnancy and the beginning of the next may, therefore, be considered a period of readjustment and rest for the internal organs. The required period of rest will, no doubt, vary in individual cases depending on many factors. Nevertheless, it is important to inquire whether there is an average optimum interval between successive births which contributes to the better health of the mother and to the more satisfactory gestation and successful completion of a subsequent birth.

Reference to this problem was first made in the Children's Bureau studies on Infant Mortality conducted in eight cities during the period 1916-1920. In two of these cities—Gary, Indiana and Baltimore, Maryland—infant mortality rates were determined by interval from the previous birth. The study in Gary, Indiana, based on 1,135 births and re-

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ported by Hughes (1), shows that the infant mortality rate was high (169.1) when birth occurred at less than 15 months after a previous birth, and was lowest (102.8) when the interval was 24 months or longer.

A more comprehensive report was published by Woodbury (2) on a study based on 7,882 births in Baltimore. Woodbury shows that the infant mortality rate was highest (146.7) when the interval was less than 2 years, it dropped to 98.6 when the interval was between 2 and 3 years, to 86.5 for an interval of between 3 and 4 years, and to 84.9 when the interval was more than 4 years.[1]

Eastman (3) recently reported the results of an interesting study based on 5,158 births which occurred consecutively on the obstetric service of the Johns Hopkins Hospital during the period 1936-1943. Not only are the rates of stillbirth and neonatal mortality according to interval from previous birth reported in this study, but also the incidence of prematurity and certain complications of pregnancy and delivery. Dividing the births into four interval groups: "very brief" (12 months or less), "brief" (13-24 months), "moderate" (25-48 months), and "long" (more than 48 months), Eastman concludes that, with the exception of the "very brief" group for which the rate is very high, the interval between births does not materially affect the welfare of mother and infant.

Eastman made an important contribution to methodology in studies of this nature by calling attention to the operation of a certain *time element* which may lead to erroneous conclusions in the evaluation of the rates in the "very brief" interval group. The effect of this *time element* may be seen from the following consideration.

A full term infant born in less than one year after a previous birth could only have been conceived during the second[2] or third month after the last birth; but a premature infant could be born within an interval of less than one year if it were conceived during the second, third, fourth, or fifth months post partum. Consequently, the full term births conceived during the fourth or fifth month are counted with the "brief"

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[1] Woodbury obtained his information in regard to interval by subtracting the age of mother (in even years) at the time of her previous birth from her age at the current birth. The length of the interval obtained in this manner is not exact.

[2] There are known cases in which conception occurred during the first month post partum but such cases are rare.

interval group, while the premature births conceived in these months are counted with the "very brief" group. Since the mortality among prematures is more than ten times that among full term infants, the calculated stillbirth and neonatal mortality rates for the "very brief" group greatly overstate the true rates. In any direct study on this subject it is important, therefore, to calculate the time interval (preferably in months) from the termination of one pregnancy to the beginning of the next, and not between two consecutive births. The rates should be based on the births that were *conceived* within a given time interval after a previous birth.

Because of certain limitations in the data, none of the three studies mentioned above may be considered conclusive. In the first place, the numbers on which they are based are not sufficiently large to take into account two very important factors: parity and age of mother at time of birth. It is well known (3, 4, 5) that the infant mortality rate, the stillbirth rate, incidence of premature birth, and many of the complications of pregnancy and delivery are greatly affected by these two factors. Since the interval between births is closely related to parity and age of mother, it is impossible to determine whether the variation in the different rates is due to the effect of interval between births or to the other two factors. In addition, the studies of Woodbury and Hughes relate to the situation as it existed more than a quarter of a century ago. Their results may not necessarily reflect the current situation in view of the progress in obstetric practices and techniques.

Because of these and other limitations it cannot be concluded that Eastman's results contradict those of the other two authors. Eastman's conclusion that the interval exerts little effect on the different rates is based primarily on the fact that in most of his tables the lowest rates were recorded for the "brief" interval group (13-24 months). This, however, may only be apparent and result from the operation of the *time element* described above. If this *time element* is responsible for the inclusion in the "very brief" interval group of an extra number of premature births which should be counted with the cohort of births occurring at 13 and 14 months after the last birth, then, by the same token, the "brief" interval group would be short that number of premature births. In other words, the *time element* operates in such a way as to overstate the rate of the "very brief" interval group and to understate that of the "brief" interval group. If the "very brief" and the

"brief" interval groups are combined, the effect of the *time element* is eliminated, and Eastman's results become more comparable to those of Woodbury.

A more important consideration in the evaluation of Eastman's material is that data from a single hospital in a community may not be the best suited for this type of investigation. Much depends on the admission policies of the hospital. In the ward services of a number of hospitals, for example, priorities are given to primiparae, and multiparae are selected for admission on the basis of complications during the prenatal period or in previous deliveries. Even in the private service there is a certain selection of cases resulting from the composition of the consulting staff. If that staff contains a large proportion of the leading obstetricians in the community, this service will receive a number of difficult cases which have been referred to the members of the staff because of previous complications in pregnancy and childbirth. Such admission policies obviously bias the results on the effect of interval because the births will not represent a random sample of all the births in the community.

This does not imply that a study on the interval between births cannot be based on hospital material. On the contrary, the only source of good material must come from hospital records. However, it must be based on the experience of *all* the hospitals in a community and the community must be such that a very large proportion of all births occur in hospitals. Preferably such a study should be made in a large city so that a sufficiently large number of births will be available to permit study of the effect of interval between births in each of the different parity and age of mother groups.

Lacking data available only through such an elaborate study, it becomes necessary in the investigation of this problem to make use of indirect methods of study. Eastman attempted to supplement his main study by such an indirect investigation based on data from the Johns Hopkins Hospital. However, because of the small number of cases available in the crucial groups no definite conclusions could be drawn. Fortunately, the Bureau of the Census publishes statistics on births and stillbirths for the entire country (6) which make possible an indirect study of the effect of interval between births based on almost a limitless number of cases.

It is the object of this analysis to investigate in greater detail the theoretical aspects involved in such an indirect study and to illustrate

by this method the effect of interval between successive births on the stillbirth rate. In subsequent papers this material will be supplemented with more detailed information available from recorded births in New York State.

MATERIAL AND METHOD

This study is based on tabulations of all the births and the stillbirths that occurred in the United States in the five-year period 1937-1941 classified according to age of mother and order of birth (parity).[3] From these tabulations are obtained stillbirth rates (the number of stillbirths per 1,000 total births) for each of the subclassifications of the births according to order of birth and age of mother.

The basic consideration in the indirect method of study is the fact that in general the interval between births for women of the same age decreases with increasing parity. For example, women in the 20-24 year age group who are being delivered of their sixth birth had had their births at closer intervals than women of the same age group who had had previously only 2, 3, or 4 births. It is, therefore, possible to investigate the effect of the interval between births by a detailed study of the stillbirth rates according to order of birth and age of mother.

The reasoning involved is probably best illustrated by the following example. The stillbirth rate for infants of women aged 15-19 years was 30.1 for second births, and 100.6 for fifth births. Thus, the stillbirth rate for fifth births for this age group was higher than the rate for second births by 234 percent. This fact in itself yields little if any information on the interval between births since the increase of the rate for fifth births may be due entirely to the parity factor. However, during the same period the stillbirth rate for *all* second births (all ages of mother) was 22.2 and the rate for *all* fifth births was 34.7, an increase of only 56 percent. Moreover, the respective rates for second and fifth births to mothers aged 35-39 were 35.2 and 40.5, an increase for

[3] There is a slight difference between "parity" as determined by the Bureau of the Census tabulations according to "order of birth" and the usually employed term. Parity refers to the number of previous *deliveries* of viable offspring. From the information on the birth certificate it is only possible to determine the number of previous viable *infants* born to the mother. However, since multiple deliveries constitute less than one percent of all deliveries, the discrepancy between the two definitions is slight and in this paper the two terms will be used interchangeably.

fifth over second births of only 15 percent. It is seen, therefore, that the extra risk of stillbirth for fifth births as compared with second births is not of the same magnitude in the different age of mother groups. It is, of course, obvious that the interval patterns are very different in these age groups. Women aged 35-39 years with five births have had these births spaced at moderate intervals while the average interval for women aged 15-19 years of para 5 was very short. Conversely, the average interval for the older mothers who had had only 2 births may be too long. Even this simple analysis indicates, therefore, that the stillbirth rate is related to interval between births; the rate may be high when the interval is either relatively short or relatively long.

This illustration indicates in general the method of approach in this indirect study. Briefly, it consists of a comparison of the manner in which the stillbirth rates vary with order of birth in one age of mother group with that in another age group. A refinement of this basic procedure is accomplished by determining "expected" stillbirth rates for the different subgroupings of the births on the assumption that interval between births does not affect the stillbirth rate. Comparison between the observed and the "expected" rates in the different classifications indicates the strength of the effect of interval between births and brings it into sharper focus.

In order to obtain these "expected" rates it is first necessary to determine the individual effects of order of birth and of age of mother on the stillbirth rate. As a first approximation it may be said that the stillbirth rates by order of birth obtained from the entire group of births (all ages of mother) afford a measure of the effect of order of birth. Similarly, the stillbirth rates according to age of mother for the births of all parities provide indices for the age of mother factor. However, this is not absolutely correct because of the very strong correlation between order of birth and age of mother. This correlation tends to overstate the extra risks of the high parities and of the older mothers. In other words, the high stillbirth rates for infants of high parity are not due entirely to the parity factor but result also from the fact that mothers of high parity are in the older age groups. It therefore becomes necessary to determine the effect of each of these factors independently of the effect of the other. This is accomplished by a method of standardization which isolates the two factors and measures the relative influence of one of the factors when the effect of the other has been

eliminated. The actual operation of the method will be illustrated in another section of this paper.

It is important to bear in mind that in the indirect method of study the actual length of interval between the current and preceding birth is not available but is obtained through an averaging process. While it is true, for example, that the average woman aged 35-39 years bearing her fifth child has had moderate intervals between births, this would not invariably be the case. Included among the mothers in this group are some who may have married late and had their births at very short intervals, and others who may have married relatively early and had their births at relatively long intervals. It can only be said that on the average, women in this group have had their births at more moderate intervals than women in the same age group who had more than five births. Consequently, the analysis is not absolute but relative and confined to a comparison of the variation of one group with that of another.

A second major consideration is that this method of study measures not the effect of one single interval but the combined effects of the interval patterns in the total previous reproductive history of the mother. For example, the excess risk of a fifth birth of a woman in the 15-19 year age group as compared to a second birth in that same age group is not due only to a short interval between the fourth and fifth births but to an accumulative effect of the very short intervals between all her births. The effect of the interval between the current and preceding births can only be seen in the analysis of births of the second order.

It is also unfortunate that the tabulations of the Bureau of the Census are given in five-year age groups rather than in single years. Since the optimum interval is apparently shorter than five years, the births of a five-year age group overlap and diffuse the effects of several intervals.

EFFECT OF THE INTERVAL BETWEEN BIRTHS ON THE STILLBIRTH RATE

The underlying conditions leading to the death of an infant *in utero* or shortly after birth are largely congenital in nature and are closely related to the health of the mother during the prenatal period. In addition, the stillbirth rate is less affected by external environmental conditions than the infant mortality rate. The stillbirth rate may thus be assumed to afford a crude measure of the health status of the mother during pregnancy and of her ability to provide an adequate environ-

ment for the satisfactory gestation of the fetus. It may, therefore, be considered among the better indices for the study of the effect of interval between births on the health of mother and infant. Its main limitation is that the reporting of stillbirths may not be as complete and as accurate as other vital statistics indices. However, incompleteness of stillbirth registration is probably not selective for the factors of order of birth and age of mother. Therefore, although the level of the stillbirth rate may be understated, the relative variation of the rate according to the factors which are pertinent to this investigation are probably not greatly affected.

Tabulations showing the distribution of births in the country according to age of mother at time of birth and according to the number of the child in the order of birth describe the different patterns of fertility experienced by different groups of the population.[4] These tabulations may therefore be viewed as providing records of a natural human experiment of tremendous scope and including a multitude of factors associated with reproduction. The stillbirth rate may be considered a useful index in measuring the degree of success of the different fertility patterns.

In Table 1 are assembled tabulations of births in the United States for the five-year period 1937-1941. Since this study relates to interval between births, only births to multiparae need be considered. In addition, births to mothers under 15 years or over 45 years of age have been eliminated since the numbers involved in these age groups are relatively small. This study is therefore based on all births of order 2 and over to mothers of ages 15 to 44 inclusive for which birth order and age of mother are known. There were 7,151,631 such births in the five-year period 1937-1941 of which 211,079 were stillbirths. The stillbirth rate for this group of births of order 2 and over was 29.5 per 1,000 total births (live births and stillbirths).

The variation of the stillbirth rate with order of birth is very marked. The rate increased continuously from a minimum of 22.2 for second births to a maximum of 115.9 for births of order 15 and over, an average increase of approximately 6 points for each birth order. The varia-

[4] In this connection, it does not follow that child spacing necessarily implies a reduction in the birth rate (see Eastman, 7). Reproductive life of women extends over a period of approximately 32 years. This period is sufficiently long to allow moderate intervals between births even if allowance is made for considerable delay in age at marriage.

TABLE 1

Stillbirth rates by order of birth and age of mother in 5-year age groups. Births to all

TABLE 1

*Stillbirth rates by order of birth and age of mother in 5-year age groups. Births to all multiparae 15-44 years of age, United States 1937-1941**

AGE OF MOTHER	TOTAL	ORDER OF BIRTH													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15+
		Stillbirth rates per 1,000 total births													
Total	29.5	22.2	26.4	30.7	34.7	37.0	40.0	44.2	49.6	54.5	60.1	67.7	75.5	89.1	115.9
15-19	33.7	30.1	45.1	74.7	100.6	138.4									
20-24	23.3	19.4	23.8	30.8	41.4	57.0	76.4	110.9	102.3	107.7	100.8				
25-29	24.5	19.7	22.6	25.7	29.0	32.7	40.4	52.4	73.9	88.3	108.4	140.1	163.5	155.8	226.2
30-34	30.4	24.0	27.5	29.8	31.9	32.0	34.1	39.4	46.8	56.9	64.6	90.5	87.1	129.2	151.6
35-39	42.0	35.2	36.6	38.9	40.5	40.8	40.3	41.1	45.1	50.7	55.5	64.4	77.6	92.6	117.6
40-44	56.2	51.5	54.1	50.8	54.3	52.2	52.5	52.5	53.7	53.1	59.9	61.3	68.7	79.0	109.4
		Number of stillbirths													
Total	211,076	62,111	40,664	28,295	20,624	15,185	11,536	9,137	7,168	5,452	3,805	2,715	1,731	1,114	1,542
15-19	11,998	8,863	2,358	592	131	53	1								
20-24	43,754	20,960	11,777	6,119	2,806	1,184	502	244	92	46	24				
25-29	52,415	16,733	11,778	8,664	6,170	3,935	2,348	1,310	735	363	182	103	51	24	19
30-34	47,636	10,129	8,720	6,952	5,754	4,645	3,717	2,902	1,973	1,280	683	443	190	119	129
35-39	38,414	4,469	4,740	4,559	4,217	3,877	3,480	3,180	2,873	2,389	1,649	1,178	763	465	575
40-44	16,862	957	1,291	1,409	1,546	1,491	1,488	1,501	1,495	1,374	1,267	991	727	506	819
		Number of total births													
Total	7,151,631	2,793,021	1,540,191	921,296	595,096	410,150	288,301	206,810	144,523	100,066	63,347	40,099	22,915	12,507	13,309
15-19	356,135	249,197	52,311	7,930	1,302	383	12								
20-24	1,875,801	1,082,585	495,693	198,593	67,798	20,786	6,570	2,200	899	427	238	12			
25-29	2,139,855	848,923	521,214	336,738	212,700	120,156	58,082	25,015	9,950	4,113	1,679	735	312	154	84
30-34	1,564,886	421,747	317,640	233,018	180,588	145,175	108,960	73,670	42,157	22,513	10,570	4,895	2,181	921	851
35-39	915,235	126,990	129,469	117,290	104,224	95,077	86,339	77,322	63,666	47,118	29,700	18,289	9,837	5,024	4,890
40-44	299,719	18,579	23,864	27,727	28,484	28,573	28,338	28,603	27,851	25,895	21,160	16,168	10,585	6,408	7,484

* Sources: Vital Statistics of the United States—Bureau of the Census
1937 and 1938: Part I, Tables 5 and 10
1939: Part I, Table 6; Part II, Table 3
1940: Part I, Table 7; Part II, Table 3
1941: Part I, Table 6; Part II, Table 3

tion of the rate by age of mother is also very distinct. The rate was at the relatively high level of 33.7 for infants of mothers aged 15-19 years. It was at a minimum of 23.3 for ages 20-24 years, and increased thereafter with age of mother to 56.2 in the 40-44 years age group.

The first indication of the effect of interval between births on the stillbirth rate may be seen from a review of the different columns of the table of rates. These show that the minimum rates for the different birth orders (the rates that are underscored in Table 1) do not occur in the same age group. Instead, the best rates appear at increasingly older age groups with increasing parity. The lowest rates among second births, for example, are found for mothers in the age group 20-24, for third, fourth, and fifth births the lowest rates are registered in the age group 25-29 years. For the births of orders 6, 7, and 8 the minimum rates are at ages 30-34 years. For birth orders 9, 10, and 11 the optimum rates occur in the age group 35-39 years. For birth orders higher than 11 the best rates prevail among infants of the oldest mothers.[5]

This shifting of the optimum rate from one age group to the next is even more striking than the statement just made. It will be remembered that the rates are available only in five-year age groups. Consequently, it is not surprising to find the minimum rates in the same five-year age group for a set of three parity groups. If data were available for single years it is very likely that each parity would have its own optimum age.[6]

[5] Incidentally, it may be instructive to view this shifting with age of mother of the optimum rate, in light of Eastman's statement that "for the best maternal and fetal outlook we are inclined to believe that youth is a better ally than child spacing." Not only do the minimum rates for the various parities occur at increasingly older age groups but they do not occur at the youngest age group for any of the parity groups. Even among second births the best rates do not occur at ages 15-19 but at ages 20-24, and for infants of order 12 and over the best rates are actually for those of the oldest mothers.

[6] In fact, it may be observed that although the minimum rate for a set of three parity groups occurs in the same age group, there is a continuous increase in the difference between the rate in that age group and the rate of the immediately preceding age group with increasing parity in the same set. For example, although the minimum rates for para 3, 4, and 5 all occur in the age group 25-29, the minimum rate for para 3 (22.6) is only slightly lower than that of age group 20-24 (23.8); for para 4 the rate (25.7) is considerably below that for age group 20-24 (30.8). For para 5 the difference becomes even greater, the rate for age group 25-29 being 29.0 compared to 41.4 for age group 20-24. It is indicated therefore that for each parity the stillbirth rate is at a minimum for a specific age of mother and that the age increases regularly and continuously with each increase in parity.

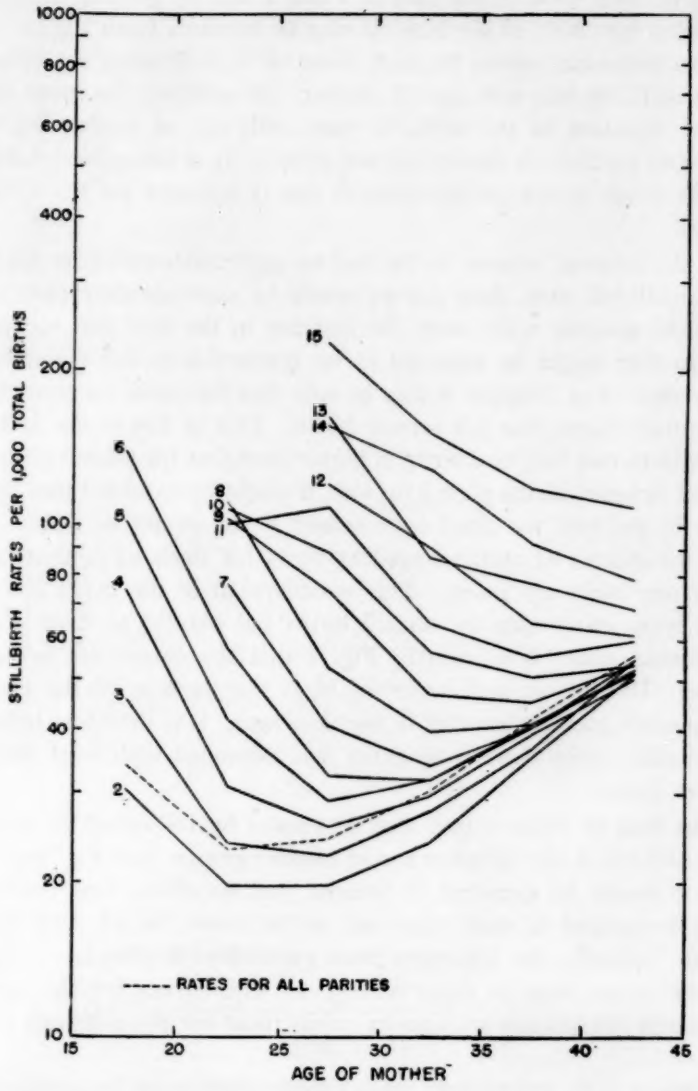

FIG. 1. STILLBIRTH RATES BY AGE OF MOTHER FOR EACH ORDER OF BIRTH AND FOR BIRTHS OF ALL PARITIES, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

Note that the curves are not parallel indicating that for each order of birth the increase in the rate is relatively greater in the younger than in the older ages.

An over-all view of the data in Table 1 and its general implication relative to the effect of the interval may be obtained from Fig. 1. This presents individual curves for each order of birth showing the variation of the stillbirth rate with age of mother. In addition, the curve showing the variation of the stillbirth rates with age of mother for total births (all parities) is shown (dotted curve). It is immediately obvious that the effect of age on the stillbirth rate is different for the different parities.

If the interval between births had no appreciable effect on the level of the stillbirth rate, these curves would be approximately parallel on a semi-logarithmic scale since the increase in the rate for one parity over another might be expected to be *proportionate* for the different age groups.[7] For example, it may be seen that the curve for third births lies entirely above that for second births. This is due to the fact that the stillbirth rate for third births is higher than that for second births. If interval between births played no role, it might be expected that the increase in the rate for third over second births would be relatively as great for infants of mothers aged 15-19 as for those of mothers 20-24 or for any other age group. This would result in the curve for third births lying above that for second births but parallel to it on a semi-logarithmic scale. It is seen in Fig. 1 that the curves are not at all parallel. Instead, in each order of birth the increase in the younger ages is much greater than that in the older ages. It is therefore indicated that in each parity there is an extra risk associated with brief intervals between births.

The data in Table 1 may also be viewed by following the rates by order of birth in the different age of mother groups (see Fig. 2). Here again it would be expected, if interval had no effect, that the curves would be parallel to each other and to the curve for all ages (dotted curve). Actually, the departure from parallelism is even more marked in these curves than in those of Fig. 1. The curves for the younger age groups rise sharply with parity, while those for the older age groups

[7] Eastman in his indirect study puts a stronger condition on the curves. He requires that they be parallel on an arithmetic scale. This requires an absolute constant increase in the rate for the different age groups. Even if interval played no role, the absolute increase from a low rate cannot be expected to be as large as the increase from a relatively high rate. All that could be expected is that the *relative* increase be the same for the different age groups. Two curves that are parallel on a semi-logarithmic scale fulfill this requirement.

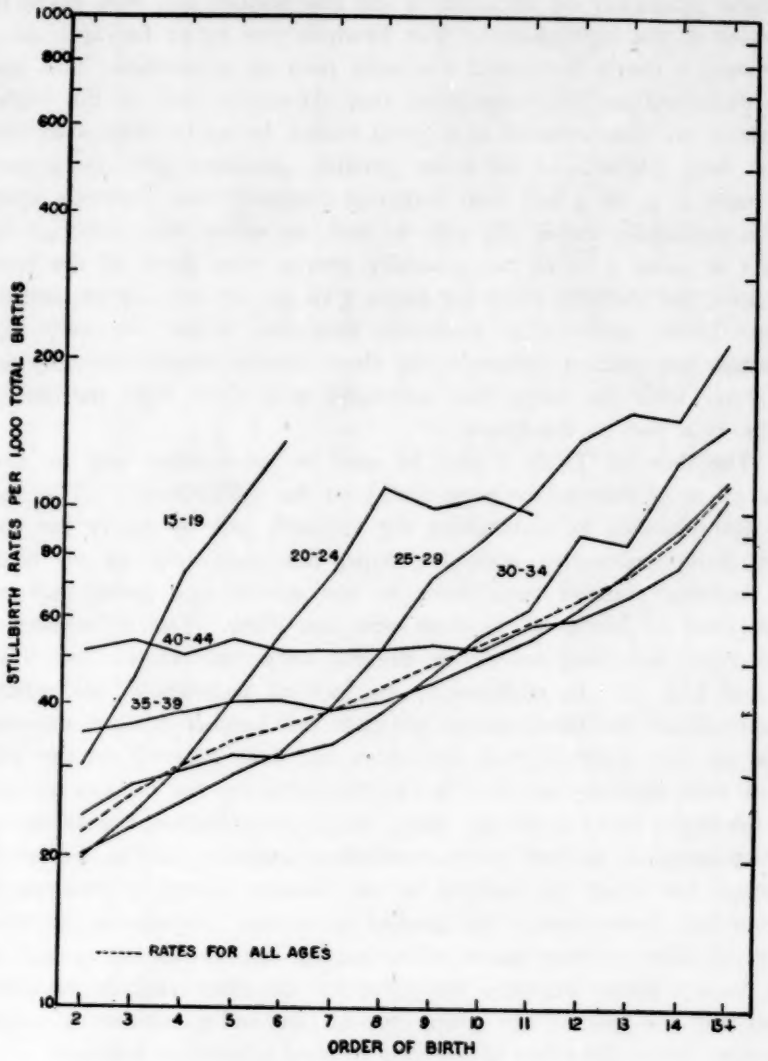

FIG. 2. STILLBIRTH RATES BY ORDER OF BIRTH FOR EACH 5-YEAR AGE GROUP OF MOTHER AND FOR BIRTHS OF ALL AGES, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

Note that while in the younger groups the rate increases sharply with order of birth, in the older age groups the variation with order of birth is slight.

exhibit practically no variation in the low parities and only slight increases at the high parities. For example, the curve for ages 40-44 presents a nearly horizontal line until para 10 is reached. This may be explained on the assumption that the extra risk of the higher parities are compensated to a great extent by extra risks associated with long intervals of the lower parities. Mothers aged 40-44 years of para 2, 3, or 4 had their births at relatively long intervals apart. This apparently raises the rate to such an extent that although the risks at paras 5 to 10 are generally greater than those of the lower parities, the stillbirth rates for paras 5 to 10 are not higher, because these births occurred at moderate intervals. When the very high parities are reached, however, the short interval comes into play and together with the extra risk associated with these high parities results in a rise in the curve.

The data of Table 1 may be used in yet another way to show the effect of interval between births on the stillbirth rate. This may be accomplished by contrasting the stillbirth rate by parity for each age group with two control groups, one consisting of all births to mothers younger than those in the specific age group and one composed of births to mothers who are older. The differences in the rates according to parity become very instructive (see Table 2 and Fig. 3). In addition to the lack of parallelism, the relative positions of the three curves of each set furnish further information on the effect of both the short and long interval on the stillbirth rate. Starting with the first set the curve for the younger mothers is far above that for the age group under consideration, but as the age group increases the two curves come closer together, and at such parity groups for which the interval in the younger group is moderate its curve falls below that of the specific age group. Conversely, the curve for the older mothers starts below that for the specific age group, but as the age group increases, the curve for the older mothers lies above that for the specific age group for an increasing number of parity groups. Here, the effect of the long interval is more in evidence.

It is important to note in these curves that age, in itself, is not the sole controlling factor in determining the level of the stillbirth rate. Although the rate generally increases with age, the curve for the older mothers in the first set is lower than any of the others. Again, although age group 20-24 is the most favorable as judged by the rate for all births, it appears favorable in these curves only for paras 2 and

TABLE 2

Stillbirth rates by order of birth and age of mother in 5-year age groups, and in each 5-year age group for births to mothers who are younger and older. Births to all multiparae 15-44 years of age, United States 1937-41

AGE OF MOTHER	ORDER OF BIRTH													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
20-24	19.4	23.8	30.8	41.4	57.0	76.4	110.9	102.3	107.7	100.8				
Younger	30.1	45.1	74.7	100.6	138.4									
Older	22.8	26.5	30.2	32.3	35.9	39.1	43.2	49.2	54.3	59.9				
25-29	19.7	22.6	25.7	29.0	32.7	40.4	52.4	73.9	88.3	108.4	140.1	163.5	155.8	226.2
Younger	22.4	25.9	32.5	42.5	60.2	76.4	110.9	102.3	107.7	100.8				
Older	27.4	31.3	34.2	33.6	37.3	38.8	42.0	47.4	56.8	58.6	66.4	74.6	88.2	117.3
30-34	24.0	27.5	29.8	31.9	32.0	34.1	39.4	46.8	56.9	64.6	90.5	87.1	129.2	151.6
Younger	21.3	24.2	28.3	32.3	34.2	44.1	57.1	76.2	90.1	107.4	140.1	163.5	155.8	226.2
Older	37.2	39.3	41.1	43.4	43.4	43.3	43.8	47.7	51.5	57.3	63.0	72.9	84.9	115.0
35-39	35.2	36.6	38.9	40.5	40.8	40.3	41.1	45.1	50.7	55.5	64.4	77.6	92.6	117.6
Younger	21.8	25.0	28.8	32.1	33.1	37.8	44.2	52.8	62.4	71.2	96.7	96.6	133.0	158.2
Older	51.5	54.1	50.8	54.3	52.2	52.5	52.5	53.7	53.1	59.9	61.3	68.7	79.0	109.4

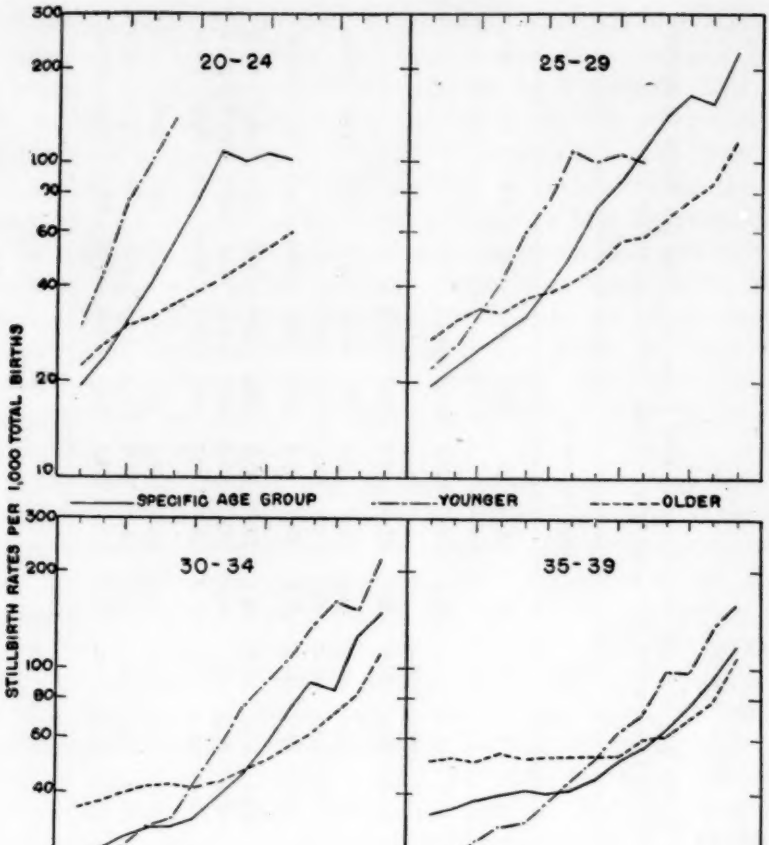

FIG. 3. STILLBIRTH RATES BY ORDER OF BIRTH AND AGE OF MOTHER IN 5-YEAR AGE GROUPS, AND IN EACH 5-YEAR AGE GROUP FOR BIRTHS TO MOTHERS WHO ARE YOUNGER AND OLDER. BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

Note the shifting of the relative positions of the three curves (see text).

3. Beginning with para 4 the rates are increasingly higher than those for infants of mothers older than 20-24 years.

From the foregoing analysis, crude as it is, it is apparent that the interval between births exerts a strong influence on the stillbirth rate. The effect is such as to increase the rate when the interval is short or long. It therefore seems worthwhile to attempt to bring these facts out more clearly by more refined analysis. This consists of determining for each order of birth and age of mother group the stillbirth rate that might be expected on the assumption that interval between births does not affect the level of the stillbirth rate. This will be attempted in the next section.

EXPECTED AND OBSERVED STILLBIRTH RATES

Reference has already been made in the previous discussion that if the interval between births were not related to the stillbirth rate then the variation of the rate by age of mother would be similar for all parities. The level of the rate would, under this assumption, be determined by the factors of parity and age of mother. If the individual effects of each of these two factors were known, it would be possible to construct theoretical rates for each of the classifications of the births according to order of birth and age of mother which would have operated if the interval exerted no influence at all. Such rates could be compared with the actual rates for an evaluation of the effect of interval between births.

As a first approximation in determining the effect of parity, the rates by order of birth for the entire group of births may be considered. Similarly, the variation of the rates by age of mother for the entire group of births may be viewed as representing the strength of the age of mother factor. The general form of these two sets of rates may be seen from the dotted curves in Figs. 1 and 2. Thus, the effect of order of birth is presented by a sharply increasing curve from a minimum for second births to very high rates for births of order 15 and over. The curve presenting the influence of the age of mother factor is U-shaped with relatively high rates for the young ages, minimum rates for ages 20-24 years, and high rates again for the older ages. However, these curves in themselves are composite and result from the combined operation of the two factors. In other words, the form of the curve by order of birth is not due entirely to the order of birth factor. It is also influenced to a great extent by age of mother because the two factors are very closely correlated. Births of high parity are also in

general those in which the mother is in the older age groups, and the mothers of the low parities are in general in the younger age groups. It therefore becomes necessary to disentangle the two factors and to determine the effect of one after the effect of the other has been eliminated. This may be accomplished by a method of standardization known as "Westergaard's Method of Expected Deaths" (8). This method may be described briefly as follows.

In each of the parity groups it is possible to determine the number of stillbirths which may be expected to occur only as a result of the distribution of the births by age of mother characteristic of that parity. This expected number is obtained by applying the total rates by age of mother to the births in the specific parity. This number of stillbirths is therefore the resultant of the distribution of the births according to age of mother if parity did not affect the rate. Comparison with the actual number of stillbirths for that parity indicates the effect of parity which is independent of the age factor. If the observed number is greater than the expected, the specific parity affects adversely the stillbirth rate. If it is lower, it may be concluded that the parity itself is a favorable one and the reason for the observed high rate is the unfavorable distribution of births according to age of mother.

The procedure yields a quantitative expression of the relative risks of the different parity groups. For example, if the observed number of stillbirths among births of order 8 is 18 percent higher than the expected number, then it can be stated that the effect of para 8 is to raise the stillbirth rate by 18 percent and this increase is due entirely to the parity factor and not to the fact that mothers of para 8 are relatively old. The actual operation of the procedure is demonstrated in the following:

In column 3 of Table 3 are shown the 206,810 births of para 8 distributed according to age of mother at time of birth. In column 2 are shown the corresponding rates for each age group which were operating on the entire group of births (all parities). Each of the numbers in column 3 is multiplied by the corresponding rate from column 2. This yields the number of stillbirths to be expected in each age group on the assumption that parity had no effect on the stillbirth rate. For example, if the 2,200 births in the age group 20-24 years were selected at random from among all the births to mothers aged 20-24 years they would be exposed to a stillbirth rate of 23.3. Therefore, 51 stillbirths would occur in this group. Similarly, the 25,015 births in the age group 25-29 years

would be exposed to a stillbirth rate of 24.5 on the basis of age of mother, and consequently 613 stillbirths would occur in that group. The same procedure is applied to each one of the age groups to obtain the

TABLE 3

Illustrative example of the determination of the number of stillbirths for births of para 8 "expected" from the characteristic distribution of these births according to age of mother (See text.)

AGE OF MOTHER	STILLBIRTH RATES FOR BIRTHS TO MOTHERS OF ALL PARITIES	NUMBER OF BIRTHS OF PARA 8	EXPECTED STILLBIRTHS RESULTING FROM THE AGE DISTRIBUTION	OBSERVED STILLBIRTHS	RATIO OF OBSERVED TO EXPECTED
Total		206,810	7,762	9,137	1.177
20-24	23.3	2,200	51	244	4.783
25-29	24.5	25,015	613	1,310	2.137
30-34	30.4	73,670	2,240	2,902	1.297
35-39	42.0	77,322	3,248	3,180	0.979
40-44	56.3	28,603	1,610	1,501	0.932

expected number of stillbirths shown in column 4. When these expected stillbirths are summed it is found that a total of 7,762 stillbirths may be expected to occur among the 206,810 births if order of birth had no effect on the stillbirth rate.

In column 5 are shown the number of stillbirths which actually occurred in each age group. These add to 9,137. It can therefore be concluded that births of order 8 are exposed to an extra risk of stillbirth which is greater than that of the average rate and that this extra risk is over and above that which may be expected from the fact that births of order 8 occur to mothers generally older than the entire group of mothers. Furthermore, a quantitative expression of this extra risk is obtained by dividing the observed number of stillbirths (9,137) by the expected number (7,762). This gives a ratio of 1.177. It can therefore be said that the effect of para 8 is to raise the stillbirth rate by 17.7 percent. The same procedure is applied to each one of the parity groups to obtain the relative effect of the different parity groups on the stillbirth rate.

By reversing the process it is possible also to determine the effect of age of mother independent of the parity factor. An illustration of this procedure is shown in Table 4. In column 3 are shown the 1,564,886

births to mothers aged 30-34 years distributed in the different parity groups. In column 2 are the rates for the different orders of birth as obtained from all the births (all ages of mother). The numbers in

TABLE 4

Illustrative example of the determination of the number of stillbirths for births to mothers aged 30-34 years, "expected" from the characteristic distribution of these births according to order of birth (See text.)

ORDER OF BIRTH	STILLBIRTH RATE FOR BIRTHS TO MOTHERS OF ALL AGES	NUMBER OF BIRTHS TO MOTHERS 30-34	EXPECTED STILLBIRTHS RESULTING FROM THE DISTRIBUTION BY ORDER OF BIRTH	OBSERVED STILLBIRTHS	RATIO OF OBSERVED TO EXPECTED
Total		1,564,886	48,742	47,636	0.977
2	22.2	421,747	9,363	10,129	1.083
3	26.4	317,640	8,386	8,720	1.040
4	30.7	233,018	7,154	6,952	0.971
5	34.7	180,588	6,266	5,754	0.918
6	37.0	145,175	5,371	4,645	0.865
7	40.0	108,960	4,358	3,717	0.851
8	44.2	73,670	3,256	2,902	0.892
9	49.6	42,157	2,041	1,973	0.966
10	54.5	22,513	1,227	1,280	1.043
11	60.1	10,570	635	683	1.076
12	67.7	4,895	331	443	1.339
13	75.5	2,181	165	190	1.151
14	89.1	921	82	119	1.462
15+	115.9	851	107	129	1.204

column 3 are multiplied by the corresponding rates in column 2 to give the expected number of stillbirths in each parity group. When these are summed, the total of 48,742 stillbirths are those which would have occurred among these births of mothers aged 30-34 years only as a result of their particular distribution according to parity if the age factor was nonexistent. Actually, there occurred somewhat fewer stillbirths than would be expected. In other words, it can be said that the age group 30-34 years does not exert an extra risk of stillbirths to multiparae and the relatively high crude rate for this age group may be attributed to the parity factor. A quantitative expression of the effect of this age group on the stillbirth rate is obtained by dividing the observed number (47,636)

by the expected number (48,742). The ratio is 0.977. In other words, for multiparae the age group 30-34 years tends to lower the stillbirth rate by approximately 2.3 percent.

Such procedures were applied to all the parity groups to obtain the ratio of observed to expected numbers of stillbirths for each parity group. These ratios are shown in Table 5 which presents for each parity

TABLE 5

Ratio of observed to expected number of stillbirths showing the relative variation by order of birth when the effect of age of mother is eliminated, and the ratio of observed rates by order of birth to the rate for all parities. (See text.)
Births to all multiparae 15-44 years of age, United States 1937-41

ORDER OF BIRTH	STILLBIRTHS			RATIO OF OBSERVED RATE TO RATE FOR ALL BIRTH ORDERS
	Observed	Expected	Ratio of observed to expected	
2	62,111	75,138	0.827	0.751
3	40,664	42,521	0.956	0.895
4	28,295	26,715	1.059	1.041
5	20,624	18,306	1.127	1.176
6	15,185	13,456	1.128	1.254
7	11,536	10,109	1.141	1.355
8	9,137	7,762	1.177	1.498
9	7,168	5,789	1.238	1.682
10	5,452	4,232	1.288	1.847
11	3,805	2,806	1.356	2.037
12	2,715	1,845	1.472	2.294
13	1,731	1,083	1.598	2.559
14	1,114	604	1.844	3.020
15+	1,542	654	2.358	3.930

the observed and expected numbers of stillbirths, the ratios of observed to expected, and the ratios of the actual rates to the total rate.

The ratios of observed to expected may thus be used to describe the relative effects of the parity factor on the stillbirth rate. These are plotted in Fig. 4 against the relative ratios obtained from the actual rates according to order of birth. It will be noted that the general effect of eliminating the age factor is to raise slightly the favorable ratios of the low parities and to lower considerably the high ratios in the high

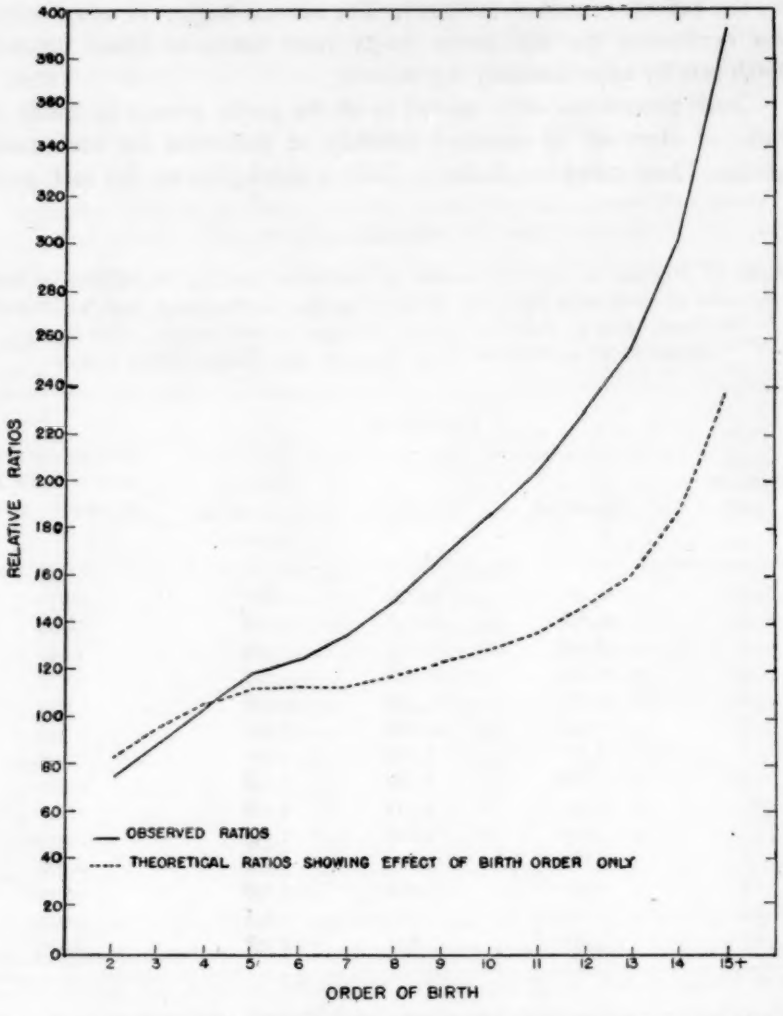

FIG. 4. OBSERVED RELATIVE STILLBIRTH RATIOS BY ORDER OF BIRTH AND THEORETICAL RATIOS WHEN THE EFFECT OF AGE OF MOTHER IS ELIMINATED, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

parities. In other words, the high rates obtained for the births of high orders are partly due to the age factor and the relatively low rates of the low parities are also due in part to the fact that births in these parities occur to mothers in the more favorable age groups.

A standardization in each of the age of mother groups yields similar ratios of observed to expected which measure the effect of the age factor and are shown in Table 6.

TABLE 6

Ratio of observed to expected number of stillbirths showing the relative variation by age of mother when the effect of order of birth is eliminated, and the ratio of observed rates by age of mother to the rate for all ages. (See text.)

Births to all multiparae 15-44 years of age, United States 1937-1941

AGE OF MOTHER	STILLBIRTHS			RATIO OF OBSERVED RATE TO RATE FOR ALL AGES
	Observed	Expected	Ratio of observed to expected	
15-19	11,998	8,214	1.461	1.143
20-24	43,754	46,781	0.936	0.790
25-29	52,415	59,117	0.887	0.830
30-34	47,636	48,742	0.977	1.031
35-39	38,414	34,352	1.118	1.424
40-44	16,862	13,733	1.228	1.908

These ratios are plotted in Fig. 5 against the ratios of the observed rates. The effect of eliminating the influence of the parity factor is to raise the favorable ratios in the lower age groups and to lower the ratios in the older age groups.

The two sets of ratios which describe the relative effects of the order of birth factor and of the age of mother factor can now be used to determine for each age and parity group the rate which would be expected to operate in that specific group only on the basis of parity and age of mother. This may be accomplished merely by raising the total rate by the sum of the effects which the specific parity and age of mother groups exert. For example, fourth births increase the stillbirth rate by 5.9 percent and the age group 15-19 years raises it by 46.1 percent (see tables above). Consequently, in order to obtain the expected rate for fourth births to mothers aged 15-19 years, the total rate (29.5) is multiplied by the product of 1.059 and 1.461. Thus the expected rate for births to mothers 15-19 of para 4 is found to be 45.6. Similarly, since

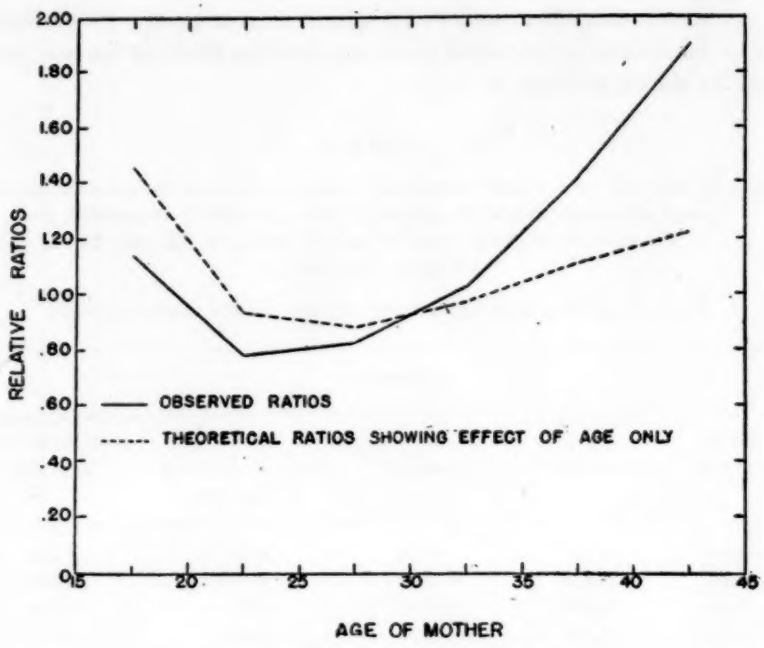

FIG. 5. OBSERVED RELATIVE STILLBIRTH RATIOS BY AGE OF MOTHER AND THEORETICAL RATIOS WHEN THE EFFECT OF ORDER OF BIRTH IS ELIMINATED, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

the age group 20-24 years tends to lower the stillbirth rate by 6.4 percent, the expected rate for fourth births to mothers aged 20-24 years (29.2) is determined by multiplying the total rate of 29.5 by the product of 1.059 and 0.936. This procedure was applied to the rates in each of the classifications of the births by order of birth and age of mother. The results are shown in Table 7.

A comparison of the different rates in Table 1 and 7 affords a method for determining in each age and parity group the relative effect of interval between births because the rates in Table 1 result from the combined effect of the three factors of parity, age, and interval between births. The rates in Table 7 are those which may be expected to result from the operation of only the two factors of age and parity. Consequently, the extent to which the rates in Table 1 differ from those in Table 7 indicates the effect of the interval between births on the stillbirth rate.

TABLE 7

Theoretical stillbirth rates resulting from the age of mother and order of birth on the assumption that the interval between births does not affect the stillbirth rate. (See text.) *Births to all multiparae 15-44 years of age, United States 1937-1941*

AGE OF MOTHER	ORDER OF BIRTH														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
15-19	35.6	41.2	45.6	48.6	48.6										
20-24	22.8	26.4	29.2	31.1	31.1	31.5	32.5	34.2	35.5	37.4					
25-29	21.7	25.0	27.7	29.5	29.6	29.9	30.8	32.4	33.7	35.5	38.6	41.9	48.3	61.8	
30-34	23.8	27.5	30.5	32.5	32.5	32.9	33.9	35.7	37.1	39.1	42.4	46.0	53.1	67.9	
35-39	27.3	31.5	34.9	37.2	37.2	37.7	38.9	40.9	42.5	44.8	48.6	52.7	60.9	77.8	
40-44	29.9	34.6	38.3	40.8	40.8	41.3	42.6	44.8	46.6	49.1	53.3	57.8	66.8	85.4	

Such a comparison is presented graphically in Fig. 6 for each birth order. As the curves in Fig. 6 are followed, the effects of both the short and the long interval become apparent.

The observed rates for second births are below the expected for births to mothers less than 30 years of age. The optimum interval in this case is the one resulting when second births occur at ages 20-24 years. The rates after age 30 are all above the expected and the difference between the observed and expected rates increases with age, an indication of the extra risk associated with long intervals.

The effect of the short interval is first noticed for third births to the youngest mothers. This effect becomes increasingly greater with

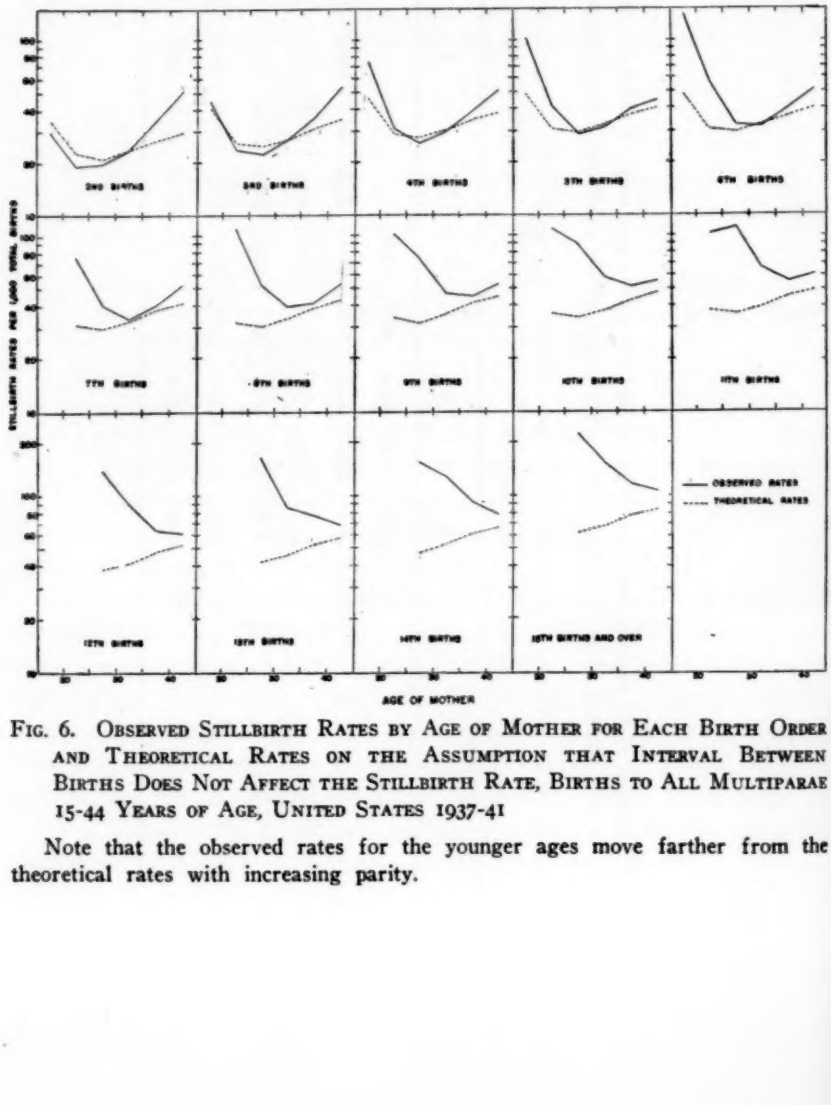

FIG. 6. OBSERVED STILLBIRTH RATES BY AGE OF MOTHER FOR EACH BIRTH ORDER AND THEORETICAL RATES ON THE ASSUMPTION THAT INTERVAL BETWEEN BIRTHS DOES NOT AFFECT THE STILLBIRTH RATE, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

Note that the observed rates for the younger ages move farther from the theoretical rates with increasing parity.

each birth order. This is due not only to a continuously shorter average interval but also to the cumulative effect of many previous births born at relatively close intervals.

A review of the curves for the higher parities indicates the adverse effect of not only the "very brief" but also the "brief" intervals because if only intervals of less than one year tend to raise the stillbirth rate, it could be expected that the rate for only the very youngest age group in each parity would lie above the expected. Actually, in each of the curves for the higher parities there are at least two, and in most cases three, of the first age groups in which the observed lie above the expected rates.

The effect of the long interval is noted in the first 8 parities. In each of these the rate in the older age groups moves further away from the expected.

It may be well to bring together the information relative to interval which may be seen from the individual curves of Fig. 6 into one curve affording a single comparison of all the birth orders. This may be accomplished by plotting for each birth order the ratios of the observed rates by age of mother to the total rate for that birth order. Such a comparison is presented in Table 8 and Fig. 7 for birth orders 2 to 10. This figure brings out strikingly the effect of both the short and long interval on the stillbirth rate.

In evaluating the curves in this figure it must be borne in mind that if interval did not affect the stillbirth rate all the curves would be superimposed on the curve for the total (the dotted curve). The relative positions of the curves is very illuminating. To the left—that is, for the younger age groups—the curves lie on top of one another in almost perfect parity order. This, of course, is to be expected because the higher the birth order for any age group the shorter the interval. To the right—that is, in the older ages—the order of the curves is reversed. The curve for second births is on top, and the curves for the higher birth orders lie each below that of the preceding birth order. This results from the effect of the long interval because the average interval becomes longer, as birth order decreases in these higher age groups. At the intermediate ages the curves come closer together indicating the relatively favorable rates of the moderate intervals. The individual curves come close to the expected ones or below them in regular fashion, that is, the lower birth orders approach it sooner than the higher birth orders

TABLE 8

Ratio of observed rates by age of mother to the rate for all ages for each order of birth. (See text.) *Births to all multiparae 15-44 years of age, United States 1937-1941*

AGE OF MOTHER	ORDER OF BIRTH													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
15-19	1.356	1.708	2.433	2.899	3.741									
20-24	0.874	0.902	1.003	1.193	1.541	1.910	2.509	2.062	1.976	1.677				
25-29	0.887	0.856	0.837	0.836	0.884	1.010	1.186	1.490	1.620	1.804	2.069	2.166	1.749	1.951
30-34	1.081	1.042	0.971	0.919	0.865	0.853	0.891	0.944	1.044	1.075	1.337	1.154	1.450	1.308
35-39	1.586	1.386	1.267	1.167	1.103	1.008	0.930	0.909	0.930	0.923	0.951	1.028	1.039	1.015
40-44	2.320	2.049	1.655	1.565	1.411	1.313	1.188	1.083	0.974	0.997	0.905	0.910	0.887	0.944

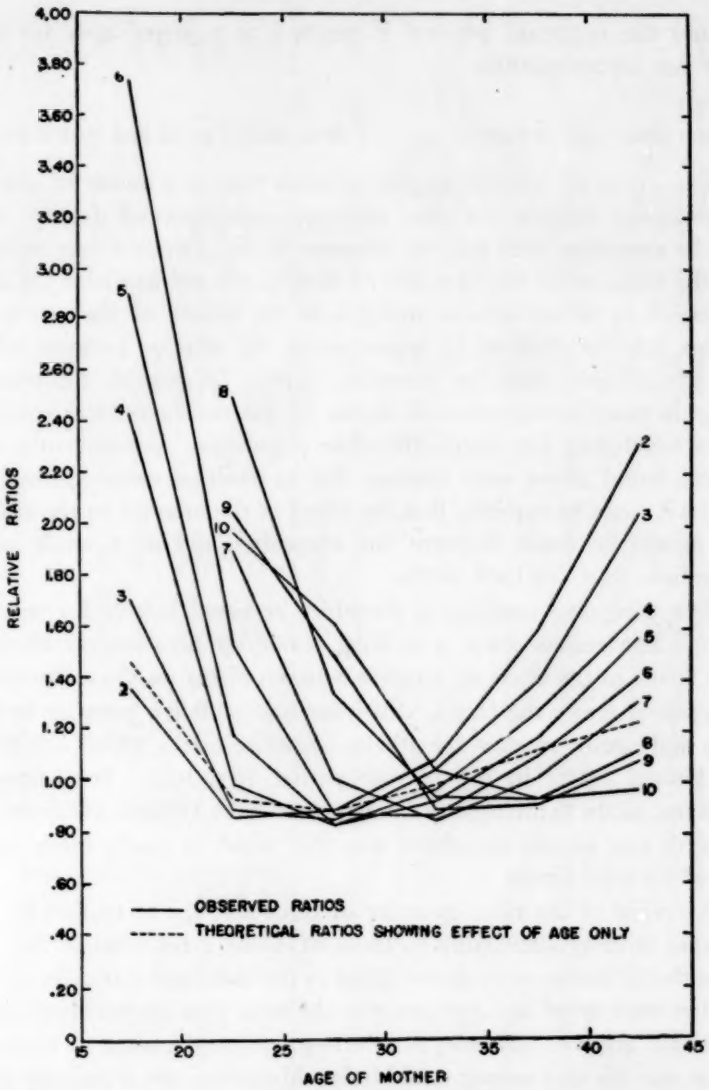

FIG. 7. OBSERVED RELATIVE STILLBIRTH RATIOS BY AGE OF MOTHER FOR EACH BIRTH ORDER AND THEORETICAL RATIOS FOR AGE OF MOTHER WHEN EFFECT OF BIRTH ORDER IS ELIMINATED, BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41

Note that to the left the curves lie on top of one another in almost perfect parity order while to the right the order is reversed indicating the effect of both the short and the long interval.

because the moderate interval is reached at younger ages for lower than for higher parities.

THE EFFECT OF INTERVAL ON THE STILLBIRTH RATE FOR NONWHITES

The effect of interval on the stillbirth rate is a result of not only physiological factors but also external environmental factors which may be associated with interval between births. Detailed data necessary for the isolation of the two sets of factors are not available. A rough indication as to the relative strength of the effects of the two sets of factors may be obtained by investigating the relation between interval and the stillbirth rate for nonwhite births. In general, the nonwhite group is more homogeneous in terms of the socio-economic conditions under which they live than is the white population. Consequently, if the results found above were entirely due to external environmental conditions it could be expected that the effect of the interval on the stillbirth rate would be much different for nonwhites and of a much smaller magnitude than for total births.

The foregoing analysis is therefore repeated briefly for nonwhite births. The results show a striking similarity between nonwhite and total births in the effect of interval between births on the stillbirth rate.

Table 9 shows the births, stillbirths, and stillbirth rates by order of birth and age of mother for all the nonwhite births which occurred in the United States in the 10-year period 1932-1941. It is based on 2,068,991 births to multiparae among whom were 117,004 stillbirths. The stillbirth rate among nonwhites was 56.6 which is nearly twice as high as that for total births.

A review of the rates by order of birth and age of mother in Table 9 shows striking similarities to those of Table 1 for total births. Here again the minimum rates do not occur in the same age group for all parities but shift from one age group to the next (see underscored rates in Table 9). Also, in this case, the shifting occurs in groups of three parities as was the case among total births. Moreover, the actual age groups at which the minimum rates occur for the different parities are identical with those found for total births. Thus, the best rates for para 2 are again found in the 20-24 year age group. For para 3, 4, and 5 the minimum rates are in age group 25-29 years. Para 6, 7, and 8 have minimum rates at ages 30-34 years. A slight exception occurs at para 9 where the minimum rate occurs at ages 30-34 years, but this rate is

TABLE 9

Stillbirth rates by order of birth and age of mother in 5-year age groups. Births to nonwhite multiparae 15-44 years of age, United States

TABLE 9

*Stillbirth rates by order of birth and age of mother in 5-year age groups. Births to nonwhite multiparae 15-44 years of age, United States 1932-41**

AGE OF MOTHER	TOTAL	ORDER OF BIRTH													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15+
							Stillbirth rates								
Total	56.6	50.0	50.8	53.2	55.6	56.7	59.7	64.3	71.1	75.3	80.9	92.4	101.2	115.1	137.0
15-19	58.4	53.0	68.4	102.4	139.0	164.1									
20-24	50.6	45.5	47.0	51.7	64.9	80.7	98.3	134.2	137.8	148.1	191.4				
25-29	52.0	49.9	46.4	46.2	47.6	51.6	61.9	73.3	96.6	109.0	119.5	183.0	185.3	177.5	230.8
30-34	59.3	61.9	58.4	56.4	54.6	50.7	50.9	57.0	64.8	75.4	88.9	117.6	120.8	163.3	169.0
35-39	70.4	78.3	68.9	71.8	64.5	60.6	60.9	60.9	65.3	69.8	74.4	87.4	101.2	117.9	145.6
40-44	78.3	101.0	75.3	88.2	71.4	72.5	65.8	68.2	73.5	70.5	75.7	74.8	88.2	95.4	122.1
							Number of stillbirths								
Total	117,004	27,262	19,796	15,567	12,294	9,640	7,720	6,399	5,161	4,109	2,915	2,226	1,508	980	1,427
15-19	11,839	8,296	2,555	737	186	65									
20-24	33,323	12,026	9,394	5,915	3,262	1,521	655	327	132	60	31				
25-29	28,169	4,276	4,719	5,017	4,597	3,599	2,543	1,540	921	472	216	155	63	30	21
30-34	20,858	1,722	2,051	2,399	2,626	2,597	2,436	2,234	1,704	1,253	762	501	253	163	157
35-39	16,981	784	915	1,235	1,348	1,500	1,706	1,807	1,825	1,713	1,299	1,042	722	452	633
40-44	5,834	158	162	264	275	358	380	491	579	611	607	528	470	335	616
							Number of total births								
Total	2,068,991	545,688	389,598	292,805	220,959	169,928	129,406	99,505	72,607	54,552	36,026	24,093	14,897	8,513	10,414
15-19	202,712	156,424	37,341	7,199	1,338	396	13	1							
20-24	658,170	264,095	200,012	114,352	50,224	18,857	6,665	2,436	958	405	162	4			
25-29	541,540	85,768	101,679	108,543	96,525	69,794	41,096	21,013	9,537	4,331	1,807	847	340	169	91
30-34	351,532	27,825	35,126	42,516	48,110	51,198	47,821	39,184	26,283	16,610	8,576	4,261	2,095	998	929
35-39	241,042	10,011	13,288	17,201	20,908	24,747	28,034	29,671	27,953	24,533	17,461	11,918	7,136	3,833	4,348
40-44	73,995	1,565	2,152	2,994	3,854	4,936	5,777	7,200	7,876	8,673	8,020	7,063	5,326	3,513	5,046

* Sources:

Birth, Stillbirth, and Infant Mortality Statistics—Bureau of the Census, 1932-1936, Tables 6 and 14
Vital Statistics of the United States—Bureau of the Census
1937 and 1938: Part I, Tables 5 and 10
1939: Part I, Table 6; Part II, Table 3
1940: Part I, Table 7; Part II, Table 3
1941: Part I, Table 6; Part II, Table 3

only slightly lower than the rate at ages 35-39 years. For para 10 and 11 minimum rates are in age group 35-39 years, and for birth orders higher than 11 the lowest rates are found in the oldest age group.

Proceeding with the analysis for nonwhites as done for total births, the variations of the rate which may be expected on the basis of order of birth alone and on the basis of age of mother alone are determined and presented in Tables 10 and 11 and in Figs. 8 and 9. It will be ob-

TABLE 10

Ratio of observed to expected number of stillbirths showing the relative variation by order of birth when the effect of age of mother is eliminated, and the ratio of observed rates by order of birth to the rate for all parities. (See text.)

Births to nonwhite multiparae 15-44 years of age, United States 1932-1941

ORDER OF BIRTH	STILLBIRTHS			RATIO OF OBSERVED RATE TO RATE FOR ALL BIRTH ORDERS
	Observed	Expected	Ratio of observed to expected	
2	27,262	29,436	0.926	0.883
3	19,796	20,777	0.953	0.898
4	15,567	15,813	0.984	0.940
5	12,294	12,267	1.002	0.982
6	9,640	9,773	0.986	1.002
7	7,720	7,740	0.997	1.055
8	6,399	6,196	1.033	1.136
9	5,161	4,692	1.100	1.256
10	4,109	3,639	1.129	1.330
11	2,915	2,472	1.179	1.429
12	2,226	1,693	1.315	1.633
13	1,508	1,064	1.417	1.788
14	980	615	1.593	2.034
15+	1,427	764	1.757	2.420

served that in general the effects of order of birth and of age of mother on the stillbirth rate are similar to those found for total births except that the effect of each of these factors is less pronounced for nonwhites than for total births. From these tables it is possible to construct ex-

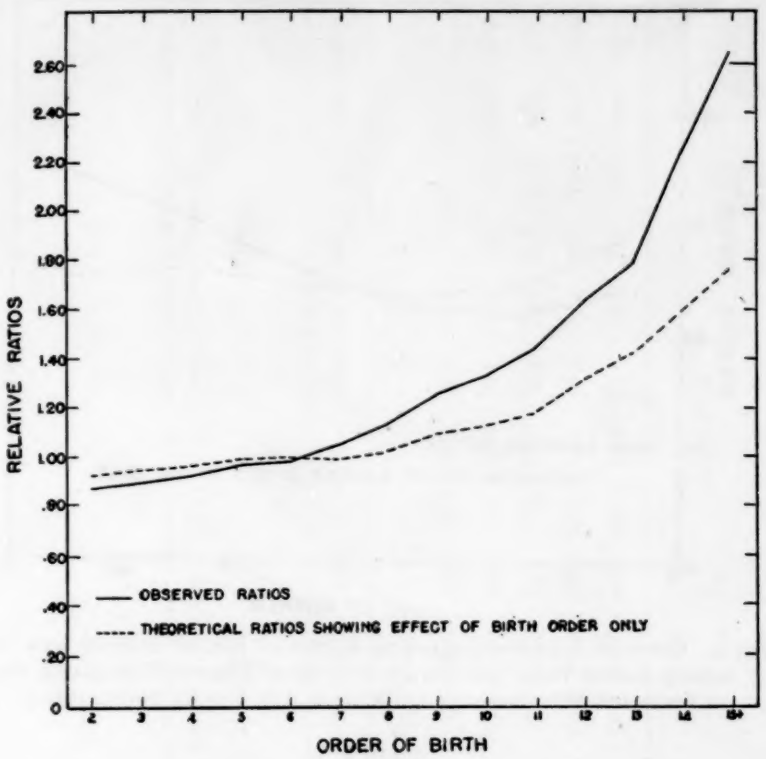

FIG. 8. OBSERVED RELATIVE STILLBIRTH RATIOS BY ORDER OF BIRTH AND THEORETICAL RATIOS WHEN THE EFFECT OF AGE OF MOTHER IS ELIMINATED, BIRTHS TO NONWHITE MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1932-41

pected rates by order of birth and age of mother on the assumption that interval between births does not affect the stillbirth rate. These rates are presented in Table 12.

From the rates shown in Table 11 and in Table 9, Table 13 and Fig. 10 have been constructed to show how the actual ratios of the rates by age of mother for each parity compare with the expected ratios on the assumption that interval does not affect the stillbirth rate. It will be noted that the variation of the individual curves for nonwhites is very similar to that found in Fig. 7 for total births.

This similarity is brought out in striking fashion by comparing the percentage increase or decrease of the observed ratios from the

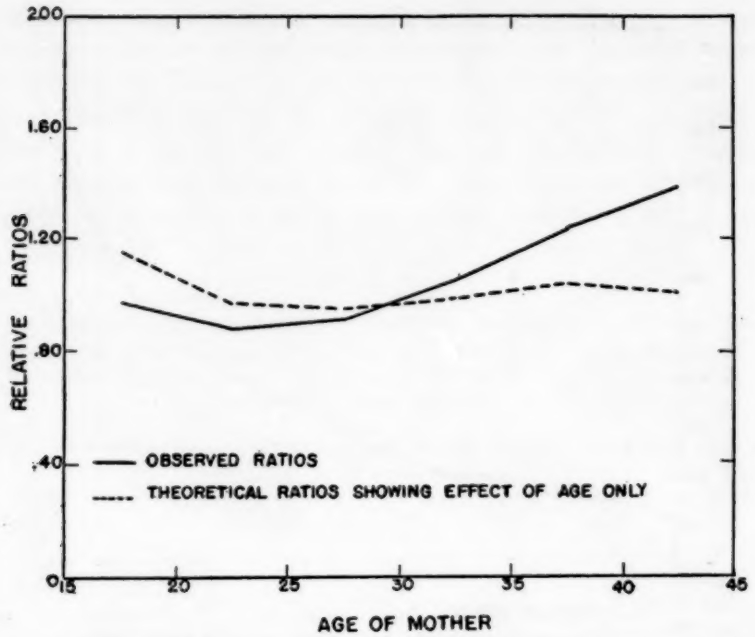

FIG. 9. OBSERVED RELATIVE STILLBIRTH RATIOS BY AGE OF MOTHER AND THEORETICAL RATIOS WHEN THE EFFECT OF ORDER OF BIRTH IS ELIMINATED, BIRTHS TO NONWHITE MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1932-41

TABLE 11

Ratio of observed to expected number of stillbirths showing the relative variation by age of mother when the effect of order of birth is eliminated, and the ratio of observed rates by age of mother to the rate for all ages. (See text.)

Births to nonwhite multiparae 15-44 years of age, United States 1932-1941

AGE OF MOTHER	STILLBIRTHS			RATIO OF OBSERVED RATE TO RATE FOR ALL AGES
	Observed	Expected	Ratio of observed to expected	
15-19	11,839	10,198	1.161	1.032
20-24	33,323	33,976	0.981	0.894
25-29	28,169	29,648	0.950	0.919
30-34	20,858	21,052	0.991	1.048
35-39	16,981	16,345	1.039	1.244
40-44	5,834	5,797	1.006	1.392

TABLE 12

Theoretical stillbirth rates resulting from age of mother on the assumption that interval between births does not affect the stillbirth rate. (See text.) *Births to nonwhite multiparae 15-44 years of age, United States 1932-1941*

AGE OF MOTHER	ORDER OF BIRTH													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
15-19	60.8	62.6	64.6	65.8	64.8									
20-24	51.4	52.9	54.6	55.6	54.4	55.3	57.3	61.1	62.7	65.4				
25-29	49.8	51.3	52.9	53.9	53.0	53.6	55.6	59.2	60.7	63.4	70.7	76.2	85.7	96.7
30-34	51.9	53.5	55.2	56.2	55.3	55.9	58.0	61.7	63.3	66.1	73.8	79.5	89.4	98.6
35-39	54.4	56.0	57.9	58.9	58.0	58.6	60.7	64.7	66.4	69.3	77.3	83.3	93.7	103.3
40-44	52.7	54.2	56.0	57.0	56.1	56.7	58.8	62.6	64.2	67.1	74.8	80.6	90.6	102.2

TABLE 13

Ratio of observed rates by age of mother to the rate for all ages for each order of birth. (See text.) *Births to nonwhite multiparae 15-44 years of age, United States 1932-1941*

AGE OF MOTHER	ORDER OF BIRTH													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
15-19	1.060	1.347	1.924	2.500	2.894									
20-24	0.910	0.925	0.972	1.167	1.423	1.647	2.087	1.938	1.967	2.366				
25-29	0.998	0.913	0.868	0.856	0.910	1.037	1.140	1.359	1.448	1.447	1.981	1.831	1.542	1.685
30-34	1.238	1.150	1.060	0.982	0.894	0.853	0.886	0.911	1.001	1.099	1.273	1.194	1.419	1.234
35-39	1.566	1.356	1.350	1.160	1.069	1.020	0.948	0.918	0.927	0.920	0.946	1.000	1.024	1.063
40-44	2.020	1.482	1.658	1.284	1.279	1.102	1.061	1.034	0.936	0.936	0.810	0.872	0.829	0.891

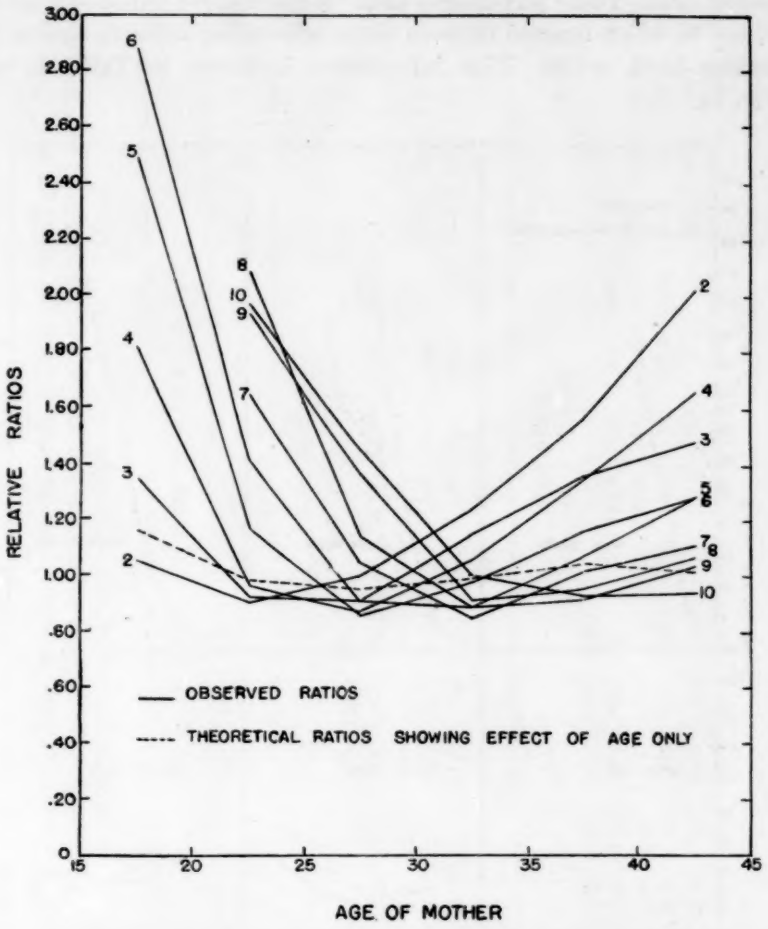

FIG. 10. OBSERVED RELATIVE STILLBIRTH RATIOS BY AGE OF MOTHER FOR EACH BIRTH ORDER AND THEORETICAL RATIOS FOR AGE OF MOTHER WHEN THE EFFECT OF BIRTH ORDER IS ELIMINATED, BIRTHS TO NONWHITE MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1932-41

Note similarity of this chart to Fig. 7 for births to all multipara.

theoretical ratios for nonwhite and for total births. In other words, for each age group it is possible to calculate, from the data given in Tables 1 and 7 for total births and in Tables 9 and 11 for nonwhite births, the percentages by which the observed rates differ from the ex-

pected rates. These percentages afford a quantitative expression of the extent to which interval between births affects the stillbirth rate in the various birth orders. This information is shown in Table 14 and Fig. 11.

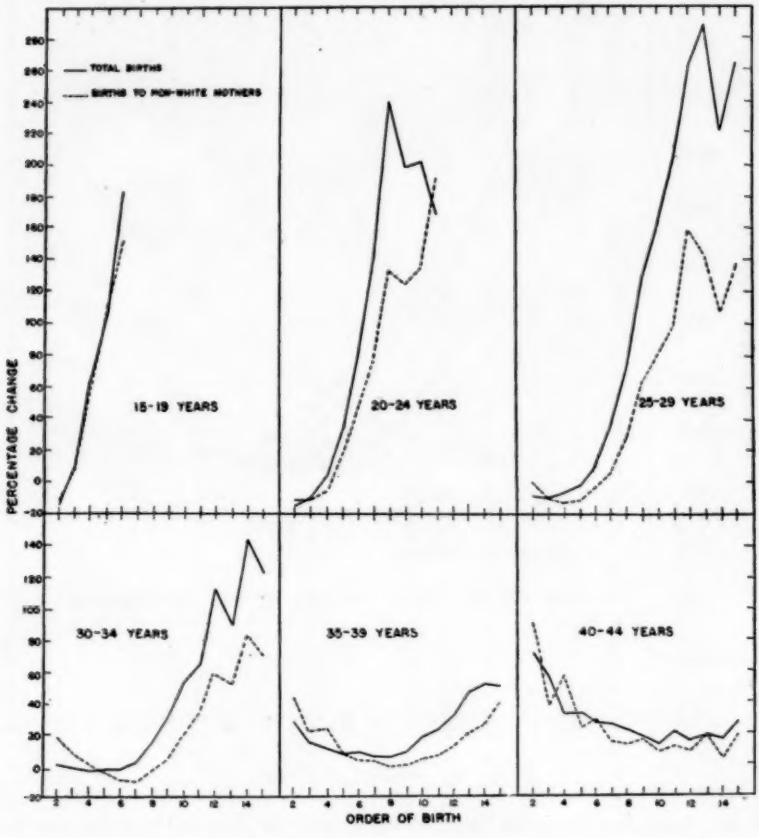

FIG. 11. PERCENTAGE BY WHICH OBSERVED STILLBIRTH RATES DIFFER FROM THE THEORETICAL RATES BY ORDER OF BIRTH FOR EACH 5-YEAR AGE GROUP OF MOTHER, FOR BIRTHS TO ALL MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1937-41 AND FOR BIRTHS TO NONWHITE MULTIPARAE 15-44 YEARS OF AGE, UNITED STATES 1932-41

Note the similarity between the forms of the curves for nonwhite and the curves for total births indicating that the effect of the interval is very similar for both. Note also the gradual change in the form of the curve from a sharply increasing curve with order of birth in the younger age groups (short interval) to a decreasing curve in the older ages (long interval).

TABLE 14

Percentage increase or decrease of observed rates from theoretical rates by order of birth and age of mother. (See text.)
For births to all multiparae 15-44 years of age, United States 1937-1941 and for births to nonwhite multiparae 15-44 years of age, United States 1932-1941

AGE OF MOTHER	ORDER OF BIRTH													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
	Total births													
15-19	−15.4	9.5	63.8	107.0	184.8									
20-24	−14.9	−9.8	5.5	33.1	83.3	142.5	241.2	199.1	203.4	169.5				
25-29	−9.2	−9.6	−7.2	−1.7	10.5	35.1	70.1	128.1	162.0	205.4	263.0	290.2	222.6	266.0
30-34	0.8	0.0	−2.3	−1.8	−1.5	3.6	16.2	31.1	53.4	65.2	113.4	89.3	143.3	123.3
35-39	28.9	16.2	11.5	8.9	9.7	6.9	5.7	10.3	19.3	23.9	32.5	47.2	52.1	51.2
40-44	72.2	56.4	32.6	33.1	27.9	27.1	23.2	19.9	13.9	22.0	15.0	18.9	16.5	28.1
	Nonwhite													
15-19	−12.8	9.3	58.5	111.2	153.2									
20-24	−11.5	−11.2	−5.4	16.7	48.3	77.8	134.2	125.5	136.2	192.7				
25-29	0.2	−9.6	−12.7	−11.7	−2.6	15.5	27.9	63.2	79.6	88.5	158.8	143.2	107.1	138.7
30-34	19.3	9.2	2.2	−3.0	−8.3	−8.9	−1.7	5.0	19.1	34.5	59.3	51.9	82.7	71.4
35-39	43.9	23.0	24.0	9.5	4.5	3.9	0.3	0.9	5.1	7.4	13.1	21.5	25.8	40.9
40-44	91.7	38.9	57.5	25.3	29.3	16.0	16.0	17.4	9.8	12.8	0.0	9.4	5.3	19.5

It is remarkable that although the level of the stillbirth rate is higher for nonwhite than for total births, and although the effect of the birth order factor and the effect of the age of mother factor by themselves are less pronounced among nonwhite than among total births, the percentage increase or decrease in the stillbirth rate which may be attributed to the factor of interval between births varies in a strikingly similar fashion for nonwhite as for total births.

The curves for ages 15-19 years are practically superimposed as are those for the oldest age group. In the intermediary age groups the curve for nonwhite is somewhat lower than that for total births but the effect of interval is very marked also in the nonwhite group.

Incidentally, the curves in Fig. 11 bring out the effect of the interval between births more clearly than any of the other curves. Thus in the young age groups the curves rise sharply with increasing parity. For example, for ages 15-19 years the observed rates are higher than expected by less than 10 percent for third births, by over 60 percent for fourth births, by more than 100 percent for fifth births. In ages 20-24 years the observed rate for para 8 among total births is almost two and one half times as high as the expected.

As the age group increases, the percentage increase of observed to expected rates with increasing parity diminishes. This is due to the fact that as age increases the average interval becomes more moderate for most parities. At the same time, the effect of long interval for low parities in the older age groups becomes apparent in the gradual change in the form of the curve from one sharply increasing with parity in the young age groups to one decreasing with parity for the older ages.

SUMMARY AND CONCLUSION

In this study an attempt is made to determine the effect of interval between births on the stillbirth rate through a detailed analysis of the rates according to parity and age of mother. It is based on more than seven million births in the country in the five-year period 1937-1941. This number is of sufficient magnitude to yield stable rates in each of the groups according to these two factors.

The rationale of the analysis is based on the fact that the interval between births for women in the same age group decreases with increasing parity. The basic method used is to determine the expected rate for each parity and age group on the assumption that the interval

between births does not affect the stillbirth rate. A comparison of the observed rates to these expected rates demonstrates the effect of the interval between births. Although this method does not yield a quantitative expression of the exact optimum interval for each parity and age group it demonstrates that relatively short intervals and relatively long intervals are associated with higher stillbirth rates while the moderate intervals lead to the lowest rates. This conclusion is based on the following facts which were demonstrated:

1. The lowest rates do not occur in one particular age group irrespective of parity. Instead, there is a consistent shifting of the minimum rate to the older ages with increasing parity.
2. When the stillbirth rates by age of mother are compared for the different parity groups the increase in the rate is not proportionate for the various age groups. The increase is very much higher for the younger age of mother groups than for the older.
3. When stillbirth rates in each age group are compared with the rates in two control groups composed of mothers younger and older than those in the age group under analysis, it is found that the control groups in which the interval is either too short or too long show higher stillbirth rates while the control groups with moderate intervals have lower rates.
4. By determining quantitatively the degree by which the stillbirth rate is affected by parity alone and then by age of mother alone, theoretical rates have been constructed which show the manner in which the stillbirth rate may be expected to vary only as a result of these two factors, assuming theoretically that the interval does not affect the stillbirth rate. The degree to which the observed rates exceed or are exceeded by these theoretical rates leads to the conclusion that for the moderate intervals the observed rates are either lower than the expected rates or are nearly equal to them.
5. A similar analysis for all nonwhite births in a 10-year period demonstrates that although the level of the stillbirth rate is higher among nonwhite births than among total births, and although the effect of the order of birth and the age of mother in themselves are less pronounced for the nonwhites than for the total, the interval between births affects the nonwhites to a surprisingly similar degree as it does the total births.

This study demonstrates that the interval between births is strongly correlated with the stillbirth rate. The results offer sufficient justi-

fication for further study of this subject with the view of determining the actual optimum intervals for the various parity and age groups. Such a study needs to be made on a very large number of births for which all the three factors, parity, age, and exact interval between births, are known. Data for such a study can probably best be secured from hospital records. It is important that such a study be undertaken in all the hospitals of one large community in which a high proportion of the births are hospitalized.

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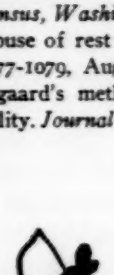

THE METOPIC SUTURE AND THE METOPIC SYNDROME[1]

BY LEO HESS, M. D.

I

THE closure of the cranial sutures is dependent upon (1) the intracranial pressure, (2) the activity of certain muscles attached to the skull, (3) certain structures of the skull, (4) the kind of suture, and (5) a certain congenital factor.

(1) The increase of intracranial pressure by the physiologic growth of the brain evidently acts as tension on the cranium—more so on the membrane of the roof than on the cartilage of the base. It produces the convexity of the vault against the physiologic basal kyphosis and prevents a premature closure of the cranial sutures.

(2) The temporal muscle (by its insertion on the zygomatic process of the frontal bone, on the crista supramastoidea, and on the parietal bone) acts during mastication on the frontal and sagittal sutures and thus interferes with their early obliteration. The masseter muscle acts on the squama temporalis, so that by its contraction the temporal bone tends to become removed from the parietale and the squamous suture is kept open. As for the coronoid and lambdoid sutures, it is the activity of the muscles of the neck (splenius and semispinalis capitis) which gives rise to tension in a direction perpendicular to the course of these sutures, i. e., in the very direction of the Sharpey fibers of the apposed bones, and may thus prevent the closure of these sutures. The sutura occipitomastoidea runs nearly parallel to the splenius and longissimus capitis. From the merely mechanical point of view it is perhaps not surprising that in children with milk teeth it is found to be closed in a high percentage of cases (12 per cent, according to Bolk, 1).

(3) The tension arising from the growth of the skull-base is transmitted, by means of the crista galli and the crista occipitalis, to

[1] I am indebted to Dr. C. Stanley Raymond, Superintendent of the Wrentham State School, for having permitted me to collect at that School some of the observations presented here.

the falx cerebri and cerebelli, and finally to the convexity of the skull vault. Furthermore, Félizet (2) drew attention to the heavy bony mass around the foramen magnum (condyli occipitales, clivus, sphenoid bone —the "centre de résistance"), which transmits the tension of the entire cranium to the vertebral column. Some bony structures around the foramen magnum, the clivus, and the sulcus sagittalis with the eminentia cruciata, are apt to transmit some of this tension to the cranial vault. Moreover, there are located in the vicinity of the foramen magnum, the crista pyramidalis and the crista alaris. The tension transmitted by all of these structures, for a certain time, at least, is able to keep the sutures open.

(4) The serrate sutures (for instance, the coronary up to the stephanion and the sagittal sutures) do not permit any lateral displacement of the apposed skeletal parts. According to Thoma (3) they usually ossify early. The harmonic sutures of the face, which are devoid of saw-toothed processes, and the squamous sutures (sphenoparietalis, sphenosquamosa, and particularly the petrosquamosa) are usually open for a longer period of time, because of the instability of their connection. It is noteworthy, however, that during infancy all the sutures are smooth. The "teeth" develop gradually. According to my personal experience, the first "teeth" make their appearance around the third or fourth year. Some sutures remain unserrated.

(5) With regard to the order of obliteration, there is a great divergence of opinion. Lenhossek (4) and Bolk (1) gave evidence that even in young children some of the sutures, particularly the sutura occipitomastoidea, and less often the sagittal and the coronary sutures, are closed in a comparatively high percentage of cases. It is common knowledge, however, that the persistence of the metopic suture is met with in certain races (e. g., *Homo alpinus*) more frequently than in others (for instance, *Homo nordicus*), a fact which undoubtedly points to a racial or congenital agent. The high percentage of prematurely obliterated sutures in children observed by Bolk is amazing (18.8 per cent in 1820 infantile crania) and may possibly be accounted for by a pathologic condition. It is interesting that in all of Bolk's cases the obliteration of the sutura occipitomastoidea started in the middle of the pars supraoccipitalis and progressed upward to the asterion. The synostosis in the lower part of the suture took place later, but it never extended to the posterior margin of the jugular foramen. The suture of the right side was closed more often than the one of the left. Without any

exception the obliteration of the sagittal suture started close to the obelion. This is consistent with the experience of many other observers. Whereas the synostosis of the sutura occipitomastoidea was more often noticed at the ages of 12 to 20, the incidence of the prematurely closed sagittal suture was highest at about the age of 6 years, without any remarkable change in children of higher age. All these facts provide evidence that a *congenital factor plays an important or decisive role in the ossification of sutures.* Furthermore, it is noteworthy that in female skulls, although their capacity and brain volume is generally smaller, the sutures are found open at later periods of life than in male skulls. This fact demonstrates again that growth of the skull and closure of the sutures are not dependent exclusively upon the development of the brain.

Metopism is extremely rare in cases with closure of the sagittal suture, and still more so with closure of the occipitomastoid suture (2 times in 272 cases of Bolk). There are apparently two types of skulls, one of which is characterized by a tendency to premature synostosis. Zuckerkandl (5) noticed many years ago that in some crania, once one of the sutures had closed, the others were prone to follow soon. According to his experience, for instance, in oxycephalic skulls, the closure of the sutures "in regione temporali"—in addition to the synostosis sagittalis—is very common. This is consistent with Greig's (6) findings.

Close analysis permits differentiation of two factors as being involved in the seemingly simple process of obliteration of sutures: the stoppage of growth of the fibrous tissue lying between the bones, and the continuation of the process of ossification, i. e., the apposition of bone tissue and the deposition of calcium salts. If the growth of the fibrous tissue and ossification stopped simultaneously, the capacity of the skull would not increase further, although the suture line would remain open. Cessation of growth of fibrous suture tissue while marginal apposition of bone continues is the manifestation of the physiological obliteration of sutures. The only exception to this rule is the frontal suture, since union of both halves of the frontal bone takes place, not by primary ossification, but through a secondarily intercalated bony mass, the so-called supranasal triangle. The sutures are the areas of growth of the skullbones, just as the epiphyseal cartilages are the areas of growth of the long bones.

At the time of puberty many epiphyseal cartilages and many suture lines undergo rapid ossification. During pregnancy certain bone changes (for instance, proliferation at the tabula vitrea) take place. Physiologic

senility is associated with definite anomalies of the skeleton (for instance, osteoporosis parietalis). It is tempting to assume that the growth of the bones is correlated with or dominated by the activity of certain endocrine organs (thyroid, hypophysis, epiphysis, parathyroid, sex glands). It should be kept in mind, however, that some epiphyseal unions remain open in puberty (at the sternal extremity of the clavicle, at the coracoid process, at the iliac crest, at the processus transversus and mammillaris of the lumbar vertebrae) and fuse later; and some synchondroses undergo ossification long before puberty (synchondrosis intraoccipitalis anterior and posterior). The order of formation of ossifying centers, varying in different individuals, is another fact which cannot easily be ascribed to endocrine agents. The same holds true of the asymmetry in length of bones common in embryos and often met with in children and adults, and of the asymmetry of shape of bones. The latter, as well as the development and structure of the spongiosa, the hypostosis and hyperostosis congenita of certain individuals, depend upon hereditary factors.[2] Aside from the laws of causality and of function generally underlying the formation and the development of all parts of the body, there is an inborn agent accounting for the individual traits and for the integration of its organs. Whether this agent, inexorably devising and ruling the individual form and fate, is to be looked upon as a physical or a spiritual one (Aristotle's ἐντελέχεια[3]) cannot be discussed in this connection.

II

It is a common belief that increased intracranial pressure due to an abnormal growth of the forebrain or to hydrocephalus internus is associated with the phenomenon of persisting frontal suture (metopism). Some authors, Schwalbe (7), for instance, expressed the opinion that persons with metopic crania may be considered of high intelligence. In view of certain considerations, to be discussed later, it is of interest to mention the following case of plagiocephalus, *in which the entire frontal suture from the glabella up to the bregma was found open:*

P. H., male, 16, imbecile, admitted to the Wrentham State School in 1934.

[2] The hyperostosis of the skull, together with early closure of sutures in cases of anencephaly, is still an unsettled problem. A congenital, as well as a mechanical factor (as a result of the lack of intracranical pressure) may be important.

[3] Aristotle's *De Anima*, 2, 1.

Born at full term, birth normal. Began to walk at 1½, to talk at 3½ - 4 years of age. The most impressive feature is the high degree of asymmetry (preauricular asymmetry) of the face, with marked deviation of the nose to the left. The right orbit as a whole is located at a higher plane than the left one. The left frontal and the left parietal eminence are flattened. Both cheeks are rather flat. The anterior part of the sagittal suture is slightly depressed; its posterior part is ridged and is open throughout, deviating to the left. The scalp slopes up behind at the lambda. The glabella is of normal size, slightly bulging. The chin is high, broad, prognathous. The zygomata, symmetric parts of both parietal bones, and the occiput are thick. The palate is broad but arched. There is a uvula bipartita. The teeth are large, particularly the upper incisors, and some of them are notched; they are crowded and their alignment is poor.

There is a marked lumbar lordosis and moderate dorsal kyphosis in the upper part of the spine. The cervical lordosis is about normal. The left foot is flat. The little fingers of both hands are deformed. The proximal interphalangeal joints of both 3rd and 4th fingers are thickened. Both big toes are extremely thick and broadened and are shorter than the other toes. The four lateral toes are nearly equal in length (isodactylia). Genua recurvata is present.

Axillae, chest, abdominal wall, the four limbs are hairless, except for a few short, brown lanugo hairs on the upper arms and along the trapezius muscles. The genital hair is black, thin, long, of horizontal outline. The thyroid gland is palpable but not enlarged. Both testicles are firm and of normal size. The apices of both lungs down to D_2 are dull upon percussion, with prolonged bronchial expiration. Ichthyosis of the entire skin is present, and there is rotatory nystagmus of both eyes. Fundi and motility of the eyes are normal; the sclerae are bluish. There is hyperactivity of the facial nerve of both sides upon mechanical stimulus (Chvostek's sign). Hyperirritability of both ulnar nerves (Hoffmann's sign) is present. The speech is guttural, but fairly clear. Tendon reflexes of both lower extremities are very active. Abdominal, epigastric, suprapubic, and cremasteric reflexes, as well as the periost and triceps reflexes, are normal. Height, 140 cm. Weight, 99 lbs.

Head Measurements

Circumference	50.6 cm.
Sagittal	15.4 cm.
Bitemporal	13.3 cm.
Bimandibular	8.8 cm.
Height (bregma-chin)	18.7 cm.
Cephalic index	86.3

Angulus Luys, capitula ulnae and many ribs are thick. Outline (profile) ovale. Muscular type. Wassermann and Schick tests negative. X-ray examination gives no evidence of increased pressure within the cranial cavity.

The parents are second cousins, the father a sex pervert. P. is the fifth of six children, all are mentally retarded.

As the cranial vault of this patient slopes up behind and not at the bregma, this case cannot be termed as true oxycephaly. The high degree of facial and cranial asymmetry, together with the cephalic index of 86.3, justify the diagnosis of plagiobrachycephaly. Consequently, it must be assumed that the thickening of the posterior part of the sagittal suture is not due to an early closure of the sagittal suture, long before the birth of the child, as this is likely to give rise to dolichocephaly. It is more likely that both the asymmetry and the prominence of the sagittal suture are the effect of external pressure at the time of birth. The fact that the delivery was normal, the father psychically abnormal, and all the children reported to be mentally retarded makes it probable that some congenital anomaly is involved, either weakness of the skull bones (hypostosis, according to Thoma) or largeness of the interstitial membranes. Under such conditions, even a normal delivery may result in a deformation of the cranium. The isodactylia, the shortness of both big toes, the deformity of the 5th fingers—all are evidence of a certain abnormality of development, as are the ichthyosis, the blue sclerae, the rotatory nystagmus, the uvula bipartita, the prognathism. There are signs of old rickets and of infantile tetany, which, according to my own investigations, are often met with in a certain muscular type of child. The skull of this patient is similar in appearance to the skull of an adult referred to by Zuckerkandl (5) as: brachycephalus, with the metopic suture not entirely closed, the other sutures of the cranium all open, and with the right half of the forehead and left part of the occiput bulging (so-called left-sided asymmetry). Thoma (3) describes a skull of a male, seven-month-old child as: plagiocephaly, with the sagittal, coronary, and frontal sutures open. In this case hypostosis was noticed.

As far as we are aware, the coincidence of plagiocephaly with metopism has not been mentioned previously in the literature. It is of interest for the considerations to be discussed in the next section. Metopism, on the other hand, is sometimes associated with encephalo- or myelomeningocele or other bony anomalies of the cranium. In Sitsen's (8) case of a two and one-half month old child the metopic suture was open, and its middle part was wide enough to form a metopic fontanel. Instead of the sagittal suture there was a large membrane (diameter, 2 cm.). In many bones of the skull there were thin transparent areas; here and there the osseous tissue was completely lacking. The great fontanel was enlarged, measuring 8 cm. in diameter, the

occipital foramen was enlarged. Meningoencephalocele posterior and marked hypostosis were present.

We therefore are inclined to suggest that all of these anomalies—metopism, spina bifida, "Lueckenschaedel," encephalocele, myelocele, and the Klippel-Feil syndrome—are based on a congenital anomaly of the bones, of the interstitial membranes, of the skull and of the central nervous system. They are related to each other and may be included under the group of anomalies known as "status dysrhaphicus." Plagiocephalus, when associated with metopism, belongs to the same group. In passing, it might be mentioned that in plagiocephaly, as well as in the cases with marked cranial asymmetry, the structure of the base of the skull appears to be normal (Zuckerkandl, 5).

III

Guided by the cases of metopic plagiocephaly, we turned to the study of metopism proper. The cases discussed below and presented in Tables 1 to 4 were those with persistent frontal suture *throughout* the frontal bone (from the glabella up to the bregma or at least up to the hair-line). Most of the patients referred to were over ten years of age.

An obvious and impressive feature of metopism is the marked facial asymmetry. This can best be observed by comparing the distances from the corner of the mouth to the outer corner of the palpebral fissure on each side. As is generally recognized, a mild degree of asymmetry of the face (the so-called preauricular asymmetry, according to Holl) is very common, although in many cases it is revealed only upon close examination.[4] Our cases showed a marked deviation of the nose, of the protruding tongue, and of the uvula. They further showed a marked prominence of one zygomatic arch or one frontal eminence; a dissimilarity of the earlobes as to shape, pattern, size, and attachment; and a dissimilarity of the depth of the nasolabial folds. These signs combined, or at least the presence of a group of them, constitute a constant and distinctive syndrome. Special mention is made of an unusually high degree of asymmetry in cases 13, 18, 21, and 45. Although it has not been mentioned in the literature, it is apparent from our studies that "metopism to the left" is comparatively rare. We observed it only in cases 27, 28, and 29, (Table 2), while in all other cases the persistent

[4] The ancient Greek sculptors were familiar with the fact, as proven, for instance, by the Venus de Milo.

TABLE 1

Metopism in the midline (or slightly deviating to the right)

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
1	M. K. ♀ 31	159	115	16.4	13.0	18.8	54.0	79.2	Imbecile. Hirsutism (cheeks, chin upper lip, 4 limbs, linea alba dark haired).	Marked bilateral syndactylia. R. nasolabial fold deeper than the l. Only the r. 5. finger deformed. Zygomata thick, glabella and supraorbital ridges smooth, R. hand, 2. finger = 4. finger. L. hand, 2. shorter than 4. Skull dark brown, early greying of hair.
2	St. R. ♂ 13 4/12		137	17.6	13.6	21.4	56.2	77.3	Chondrodystrophy (hyperplastic type). Moron.	Earlobes markedly dissimilar, not adherent. R. hand: 1. = 5., 2. = 3. L. hand: 2. = 4. R. lower leg extremely convex laterally. L. extensor trunci bigger. Glabella and frontal eminences smoothed out.
3	Z. F. ♀ 47	156	135	15.9	13.2	19.0	51.8	83.1	Tbc. fibrosa dextra. Idiocy. Rickets.	Bluish mole in the left temporal area. Papilloma below the r. orbit. Nose deviating to the l., chin to the r. Darwin's tubercle at the l. earlobe, earlobes dissimilar, both adherent. Bilateral pes cavus of moderate degree, all the toes separated. L. hand: 2. = 4. Lipoma at the l. angulus scapulae. Glabella and supraorbital ridges smooth, temporal bones above the earlobes thickened.

TABLE 1

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
4	C. S. ♀ 29 6/12	143	91	17.2	12.6	18.4	54.5	73.2	Imbecile. Tbc. fibrosa bilat. Rickets. Myelodysplasia. Hirsutism (abdominal wall, arms and legs, sacrum).	Marked bilateral syndactylia. Halux valgus bilateralis. L. nasolabial fold deeper, left face more prominent. Mammary glands different in size, r. mammilla slightly hairy. Chin and larynx strong, glabella and supraorbital ridges smooth. forehead high, the uppermost part bulging. Both 5. fingers of irregular outline.
5	J. B. ♀ 18 9/12	125	105	17.1	12.5	17.0	52.5	73.0	Cretin. Rickets. Dwarf	Bilateral syndactylia, earlobes highly dissimilar in shape and attachment, left nasolabial fold deeper. R. hand: 2. > 4. L. hand: 2. = 4. Dilated vein in the midline of the forehead, the sagittal suture slightly open. Glabella and supraorbital ridges smooth, no arcus supraciliaris.
6	S. B. ♀ 27 2/12		166	17.1	13.0	21.3	55.0	76.0	Epilepsy. Idiot	Accessory mammilla at the r. side, l. areola larger. Equinovarus dexter, the l. 3. toe the biggest; pigmented spot at the l. trapezius. R. hand: 2. = 4. finger; L. hand: 2. < 4. Earlobes dissimilar. Teeth big, very irregular.

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
7	T. R. ♀ 29 8/12	155	113	19.3	14.5	23.4	58.5	75.1	Hydrocephalus. Epilepsy. Hirsutism (thighs and lower legs, abdomen, black haired). Imbecile.	Nose deviates to the l., tongue to the r., right corner of the mouth lower than the l., skull thick, chin strong, larynx big, uvula deciates to the l., the l. earlobe deformed (artificially?). Both index fingers much bigger than the other fingers. Glabella and supraorbital ridges smooth. Zygomata not prominent.
8	C. G. ♂ 41	157	95	17.6	13.1	19.2	55.6	74.4	Moron. Hirsutism (lower arms and legs, chin, cheeks haired).	Uvula and tongue are deviating to the l., chest long, flat and asymmetric, teeth big with wide diastema, very thick zygomata, forehead steep, glabella smooth.
9	P. W. ♂ 17	155	108	15.2	11.8	16.8	50.5	77.6	Mongoloid. Mitral and aortic regurgitation.	Diastema and trema in the upper jaw, teeth in the lower crowded, of irregular shape and size, earlobes dissimilar, only the r. 5. finger deformed. Occiput flat, cervical lordosis absent, both big toes spaced, 3., 4., 5. toes almost equal in length. R. testicle small, l. bigger. Sacrum black-haired.

TABLE 1

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
10	L. B. ♀ 26	128	121	15.5	11.3	17.8	50.1	72.9	Mongolian	Bilatral syndactylia. Chin rather strong. Glabella smooth. Teeth in the upper jaw very big, irregular in size, shape and alignment. Both big toes spaced. Tongue deviates to the r. Internal strabismus to the r. eye.
11	K. E. ♂ 24 11/12	158	96	17.6	13.9	23.0	56.8	78.9	Cryptorchidism. Epilepsy. Imbecile. (Status dysraphicus)	Scrotum absent, both testicles in the groins, large, but soft. Mammillae different in size. Teeth in the lower jaw very irregular in shape. large pigmented mole at the l. buttock. Myopia: VOD: —6.50, VOS: —5.00. Normal eyegrounds. R. hand: 2. finger = 4. L.: 2. < 4. Chin high, rather strong, glabella smooth, zygomata and rami of mandible bone thick, both feet very long (length 27 cm.; instep 22.0). Lumbrosacral area markedly hairy, l. abdominal and both cremasteric reflexes absent.
12	E. U. ♀ 39 6/12	148	104	15.2	9.8	17.1	51.1	64.4	Moron	Nose deviates to the r., earlobes outstanding, of simple pattern, dissimilar, iris greyish green, in the left many brown spots. High degree of webbing between 2. and 3. toes of both feet. R. tibia bent. Palate broad, glabella smooth.

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
13	B. E. ♀ 15 8/12	148	83	15.6	12.4	18.2	50.8	79.4	Imbecile	Highest degree of facial asymmetry. L. eyeslit larger than the r., nose deviating to the l., l. papilla cleft, r. half of the upper lip considerably larger than the l., both 5. toes extremely short. R. sternoclavicular joint thick. Glabella not prominent, palate broad, teeth irregular.
14	B. C. ♂ 18 9/12	165	79	31.5	16.5	21.6	67.0	52.3	Moron. Hydrocephalus congenitus. Kyphoscoliosis.	Syndactylia (of 2. and 3. toes) of high degree, bilateral. 4. toes shorter than the 5. L. mammilla small, pinkish, r. bigger, dark brown. R. nasolabial fold deep, l. shallow. R. half of the chest flat. Kyphoscoliosis lumbodorsalis of high degree (instrumental delivery). Spasticity of both legs. Glabella broad, smooth.
15	M. J. ♀ 38½	149	105	16.0	12.2	17.5	51.8	76.2	Deaf and dumb. Imbecile	Earlobes dissimilar. Big lump in the l. mamma (cystadenoma). External strabismus of the l. eye. R. nasolabial fold deeper. Fat deposit exclusively to the lower abdominal wall. Palate broad and high, glabella narrow and smooth. Larynx weak.

TABLE 1

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
16	L. St. ♀	158	109	15.5	13.5	21.5	52.6	87.0	Moron	R. mammilla more prominent, darker, with black hairs. Earlobes of very different shape. Brown spot in the lateral portion of the r. sclera. Zygomata and chin big, glabella smooth. Palate high and broad.
17	A. L. ♀ 27 3/12	137	130	16.3	12.2	19.2		74.8	Imbecile. Rickets. Cystadenopathia mammae sin. Hirsutism (legs, chin, upper lip, cheeks).	Left nasolabial fold shallow, tongue big, deviates to the l., earlobes dissimilar, the l. gastrocnemius much bigger, r. hallux valgus, teeth big, irregular in size. Zygomata big, glabella and supraciliary arches smooth. Lumbar area strongly dark-haired. Palate high, narrow.
18	D. W. ♀ 25 8/12	144	91	16.3	11.8	19.9	50.2	72.3	Imbecile. Rickets	Moderate bilateral syndactylia (2. and 3.). Face highly asymmetric, the r. eyeslit narrower, r. half of the face depressed, and l. zygoma prominent. Epicanthal fold of the r. eye, the l. second toe bigger than the r. one. Teeth irregular, occlusion poor. Tongue deviates to the r. Palate broad.

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
19	M. T. ♀ 25 9/12	144	92	16.7	13.1	19.8	53.8	78.4	Imbecile. Rickets	Moderate bilateral syndactylia (2. and 3.). R. hand: 2. = 4. L. hand: 4. > 2. L. nasolabial fold shallow, nose deviates to the r. Slight degree of hallux valgus at the r. side. R. papilla fissured, flat, the l. prominent. Teeth strong, irregular in size and shape, palate broad, high; mastoid processus and zygomata big. Parietal and frontal bosses bulging.
20	J. L. ♀ 28 2/12	145	105	18.6	13.2	21.2	58.4	62.2	Idiot. Rickets. Hirsutism (chin and cheeks to be shaved twice a week. Virile appearance).	Nose deviates to the l. R. hand: 2. = 4. finger. L., 4. > 2. L. areola mammae dark brown, r. pinkish. Earlobes dissimilar. Antihelix triangular; palate high, arched. Caput quadratum, chin strong, occiput bulging. R. sternoclavicular joint thick. Bilateral isodactylia.
21	W. U. ♀	118	64	15.3	11.5	16.8	49.2	75.1	Mongoloid, Old rickets	Caput quadratum with steep forehead and bulging occiput, cheeks flat, glabella smooth, chin and zygomata big. Earlobes misshapen, slightly dissimilar. R. foot: 3. = 4. = 5. toe. L. foot: toes of regular length. Teeth most irregular. Some of them notched. Chvostek's sign to the r. side positive.

TABLE 1

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
22	J. L. D. ♀ 39	134	88	17.0	12.3	19.6	52.3	72.3	Epilepsy. Rickets. Imbecile	Moderate bil. syndactylia (2. and 3.). Strabismus convergens of the l. eye and bil. nystagmus rotatorius. Tongue deviates to the r. R. nasolabial fold shallow. Hairy mole at the inner aspect of the r. thigh. Occiput bulging, Chvostek's sign positive. The high skull and the strong, big chin are out of proportion to the frail frame.
23	T. R. ♀ 70	164	124						Tbc. fibrosa bil. Pruritus senilis.	Earlobes greatly dissimilar. The r. sternoclavicular joint thickened, tongue and septum nasi deviating to the r. Infrequent attacks of hives. Small diaphragmatic hernia.
24	H. F. ♀ 45 8/12	165	136	16.8	13.8	21.2	54.8	82.1	Imbecile. Rickets	Syndactylia (2. and 3. toe) only at the r. foot. Upper jaw prognathous with 2 very big med. incisors. Glabella smooth, frontal bosses not bulging.
25	M. J. ♀ 46 4/12	144	92	16.7	13.1	19.8	53.8	78.4	Imbecile. Rickets	Moderate syndactylia (2. and 3.) on both sides. R. hand: 2. = 4. finger. L. hand: 2. < 4. Nose deviates to the r. Left nasolabial fold shallow. Positive Chvostek's sign.

TABLE 1

Metopism in the midline (or slightly deviating to the right)—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
26	C. A. G. ♀ 42	157	95	17.6	13.1	19.2	55.6	74.4	Tbc. fibrosa sin. Moron. Hirsutism (upper lip, chin, cheeks, forearms, legs. Lumbrosacral area hairy)	Tongue and uvula deviate to the l., shape of earlobes different, as are both papillae. Glabella smooth. Zygomata thick. Teeth big, with marked diastema.

TABLE 2

Metopism to the left

TABLE 2

Metopism to the left

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
27	P. H. ♂ 15 10/12	140	99	15.4	13.3	18.7	50.6	86.3	Ichthyosis. Tbc. fibrosa pulm. sin. Imbecile. Old rickets.	Facial asymmetry of highest degree with the skull sloping up behind the bregma, the nose deviating to the l. Teeth very irregular, extremely notched, crowded. R. orbita higher than l., l. half of forehead lowered, bifurcated uvula, lower lip bulging, palate broad and high, chin strong. Infantile thorax.
28	M. H. ♂ 18 8/12	173	95	18.3	13.6	19.3	56.5	74.3	Imbecile. Old rickets. Vitiligo. "Petit mal." Cannot talk.	Moderate bilateral syndactylia. Left-handedness. Earlobes dissimilar, the l. one outstanding. Teeth in lower jaw crowded, in upper spaced, some with marked enamel defects. Chin strong, zygomata big. Occiput enormously thick. Glabella smooth.
29	B. F. ♂ 9	95	61	16.4	14.5	19.8	53.8	88.4	Birth injury. Hydrocephalus. (Markedly enlarged lateral and 3. ventricles, large excess of hair over periphery). Paralysis of l. abducens. Heterochromia of trides. Rickets. Cannot talk.	Teeth large, spaced, extremely irregular, tongue deviating to the r. Glabella smooth and broad. Zygomata prominent. Chin strong. Flaring ribs.

TABLE 3

Metopism with definite organic cerebral lesion

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
30	V. B. ♀ 9 8/12		25				55.5		Porencephaly with multiple congenital cysts of brain Pneumoencephalogramum (October, 1939) Hydrocephalus.	Ant. fontanel open. L. eyeslit larger than the r.; l. pupil bigger than the r. Epicanthus at the r. side, the l. 3. toe the biggest. Isodactylia at the r. foot. Upper incisors very broad, irregular in size. Prematurely born.
31	E. W. ♂	176	117	19.1	13.9	23.6	58.1	72.7	Brain atrophy. Dilated ventricular system, subarachnoid cysts. Birth injury (Cesarian section). Rickets.	Bilateral syndactylia (2. and 3.) of moderate degree, the r. zygoma greatly bulging. Bregma prominent, glabella normal in size, slightly prominent. Teeth large, crowded. Both big toes very thick, plump; feet flat, long (25 cm. length; 25.2 instep). Many signs of old rickets, the skull out of proportion to the rather frail body build. Index and middle finger of the r. hand deviate to the ulnar side.

TABLE 3

Metopism with definite organic cerebral lesion—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
32	J. S. ♂								Birth injury (Cesarian section), involvement of the l. hemisphere and of both pyramidal tracts. Hydrocephalus int. Mitral insufficiency. Tic.	Uvula and tongue are deviating to the r., earlobes dissimilar in shape and length, the l. being longer. L. foot flat, the r. equinovarus. Eyes slanting. R. lower abdominal reflex missing. Rossolimo and Mendel reflexes only at the r. side. Bilateral patellar, ankleclonus. Big frontal eminences, palate broad; glabella broad and smooth, occiput thick, bulging; teeth partially missing.
33	F. A. ♀ 20 11/12	138	93	15.8	12.6	18.7	52.0	79.7	Tic facial. Hirsutism (upper lip, both legs, abdominal wall, lumbrosacral area). Imbecile.	Moderate bilateral syndactylia, r. hand: 2. = 4. L. hand: 2. < 4. L. scapula scaphoid. 2 r. toe the biggest. Darwin's tubercle at the r. helix. Slight strabismus divergens of the l. eye.

TABLE 3

Metopism with definite organic cerebral lesion—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
34	B. W. ♀ 17 10/12	143	104	16.0	13.2	18.5	44.9	82.5	Birth injury. Chorea. Moron.	Lower jaw prognathous. L. earlobe outstanding. Syndactylia (2. and 3.) only at the l. foot. Tongue deviating to the l.; upon opening the mouth, the lower jaw deviates to the l. Sturdy, muscular legs.
35	M. F. ♀ 18 1/12	136	103	14.9	14.3	20.3	51.8	95.9!	Imbecile (Lues hereditaria?) Involvement of both pyramidal tracts.	Mammary glands different in size. R. big toe particularly large. Moderate bilateral syndactylia (between 2. and 3.). Palate high and broad. Teeth strong, some of them spaced and notched. Zygomata large, chin high, glabella broad, flat. Bilateral Rossolimo and Babinski signs, knee and ankle jerks increased.
36	N. L. ♂								Birth injury, congenital bilateral dislocation of hips. Epilepsy.	Nose deviating to the l., the r. eyeslit slanting inward, the l. horizontal; earlobes dissimilar. Teeth very irregular, palate high, narrow, arched. Glabella broad, smooth. (The r. iris brown, the l. greyish).
37	C. F. ♂ 9 8/12	120	69	14.1	12.2	15.5	50.0	86.5	Involvement of the l. hemisphere. Idiot.	Bilateral syndactylia (2. and 3.). R. equinovarus, strabismus convergens of the l. eye, large coloboma of the l. retina, cleft palate, bifid uvula, earlobes dissimilar (l. iris grey, the r. darker). Paresis and spasticity of the r. leg.

TABLE 3

TABLE 3

Metopism with definite organic cerebral lesion—Continued

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
38	G. C. ♂ 13 8/12	155	98	17.8	12.7	20.0	54.0	71.3	Imbecile. Prematurely born.	Tongue deviating to the r. Teeth irregular, whirl to the r. Both eyeslits out- and downward slanting, the r. 5. finger deformed. Iris greenish grey with brown dots of different size and distribution in both eyes. Chin strong, zygomata and glabella prominent.
39	M. S. ♀ 40	152	120				54.0		Parkinsonism after encephalitis. Moderate degree of hirsutism (hairs on the lower legs and thighs, upper lip, chin, linea alba, both cheeks).	L. enophthalmus and narrowing of the l. eyeslit. R. arm markedly larger than l. throughout. In the l. iris many small and one larger dark brown spot in the lower, lateral quadrant.
40	Dr. E. L. ♂ 41								Status dysrhaphicus.	Sacrum hairy with a pigmented mole at the r. side. L. eye slightly protruding. L. eyeslit larger. In the l. iris many brown spots. Both superficial cremasteric reflexes absent. Thyroid gland slightly enlarged.

TABLE 4

"Microcephalic"

CASE	NAME SEX AGE	HEIGHT (cm.)	WEIGHT (lb.)	HEAD MEASUREMENTS: Sagittal (cm.)	Bitemporal (cm.)	Height (cm.)	Circumference (cm.)	Cephalic index	DIAGNOSIS	REMARKS
41	E. U. ♀ 40 6/12	148	104	15.2	9.8	17.1	51.1	64.4	Moron. Rickets.	High degree of webbing between 2. and 3. toes of both feet. Nose deviates to the r. Earlobes different in shape. Chvostek's sign positive. R. tibia bent.
42	F. U. ♀ 36 3/12	143	107	15.6	11.8	16.6	49.9	75.6	Moron. Rickets.	Moderate syndactylia (2. and 3.) at the r. foot. Nose deviates to the l., r. nasolabial fold shallow. Paresis of the l. abducens, the lower l. leg weaker than the r. (circumference r. 32.2 cm.; l. 29.8). Earlobes dissimilar.
43	G. U. ♀ 44 5/12	133	80	16.1	11.6	18.6	51.0	72.0	Imbecile (low grade). Rickets. Dry eczema.	Nose deviates to the l., l. forefinger deviates to the ulnar side. R. papilla fissured.
44	R. M. ♀ 27 8/12	151	94	16.0	11.9	19.7	50.8	74.3	Imbecile. Twin. Old tbc. of the r. lung. Rickets.	Earlobes dissimilar. R. hand: 2. > 4. L. hand, 2. = 4. Tongue deviates to the r. L. papilla inverted. In the l. mammary gland a firm, moveable mass can be felt. A brown mole at the sacrum. Strabismus convergens of the l. eye.
45	B. E. D. ♀ 15 8/12	148	84	15.6	12.4	18.2	50.8	79.4	Imbecile with little impediment to the speech.	Facial asymmetry of high degree. Cleft in the l. papilla. L. eyeslit larger than the r. R. half of the upper lip larger. Nose deviates to the l. Both tragi deformed, both 5. toes extremely short.

frontal suture was located precisely in the midline or deviated slightly to the right with reference to the middle of the glabella. Anatomical study of metopic skulls showed that in the majority of the cases we had occasion to examine the frontal suture was continuous with the sagittal suture, and in only a few instances did it deviate slightly to the right. This was true of skulls of children as well as of adults.

In an attempt to explain these observations, it is best to start with the generally accepted assumption that a relation exists between the development of the brain and that of the skull. Either the brain develops according to its law and the skull is dependent upon the development of the brain, or brain and skull represent, from the developmental point of view, one unit. The latter hypothesis will prove to be helpful in our discussions on oxycephaly. The left inferior frontal gyrus is universally considered to be more developed than the right one. This fact, along with the right-handedness of the majority of human beings (according to my personal experience with European populations there are about 6 to 8 per cent left-handed individuals), points to a certain predominance of the left hemisphere and probably also of the left half of the frontal bone, thus pushing the metopic suture slightly to the right. In this connection it is not without interest to recall a case described by Thoma (3): No. 1, child, 3 months old, with metopism, all of the sutures patent, myelomeningocele lumbalis. Thoma noticed asymmetry of the cranial vault, asymmetry of the anterior fontanel, and a comparatively larger left hemisphere. The impressiones digitatae in this skull were deepest in the area of the left lobus parietalis and of the left gyrus centralis.

As a confirmatory sign demonstrating some local abnormality within the brain case, the occurrence of a dilated, more or less tortuous vein in the forehead along the metopic suture may be mentioned. The veins of the exterior of the cranium and of the forehead communicate with the superior sagittal sinus. Any pressure upon or displacement of the latter may result in an impediment of the venous return and cause dilatation of the superficial frontal vein.

In some of the cases (10, 29, 37, 44) paresis or paralysis of the left abducens nerve indicates an involvement of the left midbrain. None of these cases complained of pain in the face.

Of the cases with left-sided metopism, one patient (28) is left-handed (with a possible predominance of the right hemisphere). He also suffers from epilepsy. Since Redlich's (9) and Steiner's (10)

studies, the coincidence of epilepsy and left-handedness in a certain percentage of cases is a recognized fact. Case 28 had general convulsions in the first days of life. He is unable to speak, probably as a result of a defect of the left frontal lobe. In case 29 defect of speech and weakness of left abducens were noticed.

Whereas in Tables 1 and 2 we are dealing with brains rather diffusely damaged, in the next group (Table 3) a more localized lesion can be assumed. We made the following diagnoses: porencephaly (30), atrophy of cortex (31), tic (33), tic with involvement of the left pyramidal tract, following birth injury (32), chronic chorea (34), mental deficiency following birth injury (35). The last is mentioned in cases 14, 29, 30, 31, 32, 34, 36, and 38 (premature). Mechanical displacement of some bones of the skull, along with damage to the brain tissue, is to be considered in these cases.

In our studies on heterochromia of the iris (11), attention was called particularly to the glabella, which was found to be flat or slightly depressed and rather broad (euryprosopia). As the width of the glabella is determined by the nasel portion of the frontal bone and the development of the latter is closely connected with the growth of the frontal lobe, it seemed of interest to mention patients in whom metopism was associated with heterochromia, particularly since this coincidence has never been reported in the literature.

By the term "microcephaly" we mean in this paper a cranial reduction characterized by a circumference of the skull in an adult patient of about 50 cm. or below. The stature of all the patients, with the exception of case 44 and the mongolian (21), was below five feet, which means that they could be regarded as dwarfs. The classical bony changes of the microcephalic skull *sensu stricto* were missing. This conforms with the experience of Brushfield and Wyatt (12), who met with the characteristic picture in not more than 70 cases in a group of 1185 imbecile and idiot children. Aside from imbecility of higher or lesser degree (2 microcephalics are mentioned as mongolians in Table 1), paresis of the left abducens nerve were present in two cases; in one (41), a positive Chvostek's sign was noticed. Three "microcephalic" patients (41, 42, 43) are sisters. True microcephaly too is sometimes familial.[5] As already stated, the base of the skull in microcephaly is the least involved or

[5] Famous is the Baker family of five microcephalics. Thersites was apparently microcephalic (*Ilias* 2, 219).

is free from bony changes. Even macrogyria, sometimes observed in microcephaly, rarely affects the basilar part of the brain.

In four instances of "microcephaly" in the broader sense (41, 42, 43, 44) and in one microcephalic mongolian idiot (21), signs of old rickets were manifest and a connection between this disease and the stunted growth of skeleton and skull is possible. The evidence of rickets might possibly provide a means of differentiating this picture from the true, classic microcephaly, which apparently is endogenous and not rachitic. It is worth remembering that mongolism is altogether independent of rickets and that in the mongolian (10) and in two cases with the highest degree of facial asymmetry (13, 45), the diagnosis of rickets could not be established. In spite of the smallness of the brain, and with no evidence of a rise in intracranial pressure, the metopic suture remained open. X-ray studies did not reveal any other suture to be patent. It has been mentioned that in cases of anencephaly all of the existing sutures were found closed. In classic microcephaly frequently the sutures likewise are said to be closed.

In all our cases, measurements were taken of:

(1) the hemicircumference of the chest and of the distance of the nipples from the midline in males;
(2) the length of both clavicles; and
(3) the distance of the crista iliaca superioris from the midline.

Except for the case with scoliosis (14) no marked asymmetry could be observed.

The marked and almost constant asymmetry of the visceral cranium in our opinion is an objective sign of an anomaly—either congenital or acquired in early life. Clinical and roentgenological signs of increased intracranial pressure were lacking in all of the cases. Furthermore, it is noteworthy that in several cases of children with hydrocephalus of different origin (rickets, lues, old meningitis), metopism could not be found.

Although these studies did not reveal any marked asymmetry of the trunk, there were many signs of asymmetry demonstrable in the hands and feet besides those in the visceral cranium. Pryor (13) in his extensive X-ray studies gave evidence that the ossification of the bones took place symmetrically. In contrast to this our investigations revealed some data that are important for various reasons. Comparing the length of the fingers of both hands we noticed in cases 1, 6, 11, 19, 20, 25, 33 that the 2nd finger was equal to the 4th in the right hand,

whereas the 2nd finger was shorter than the 4th in the left hand. In cases 5 and 44, the 2nd finger was equal to the 4th in the left hand, whereas the 2nd finger was longer than the 4th in the right hand. Bilateral isodactylia was observed in cases 9 and 20, while unilateral isodactylia was present in cases 21, 30 (in both cases on the right side). The 5th finger was seldom involved (one-sided in cases 1 and 38, bilaterally only in case 4). This fact is rather remarkable, since in most of the cases of status dysrhaphicus the 5th fingers are both deformed. The thumb was always spared. The 4th toes were extremely short in case 14. The 3rd toe was found to be the biggest in cases 6 and 30. The left big toe was markedly longer than the right in case 18. Occasionally we observed hallux valgus (4, 17), but never hallux varus, this fact being noteworthy because of the frequent occurrence of hallux varus in acro- and scaphocephaly (Park and Powers, 14). Originally the second toe is the longest; such is often the case in babies and children. In adults we usually find that the big toe is the longest in the majority of cases (about 86.7 per cent, according to Braus, 15). In classic Greek statues the predominance in length of the second toe is common. What matters in this connection is, first, the lack of symmetry; second, the occasional abnormality in the size of the fingers and toes; and finally, the surprising and interesting observation that the fifth and, even more so, the first fingers are spared. In two cases (11, 31) the feet were disproportionally long (podomegaly). There are many reasons to believe that certain bone anomalies—acromegaly, arachnodactylia, brachydactylia in mongolians—are intimately connected with the disturbed function of the anterior lobe of the pituitary body. In the introduction it was remarked that the "epiphyses" of the skull, the suture lines, their function and closure, are possibly related to the activity of certain endocrine organs, as are the epiphyses of the long bones. Furthermore, we are familiar with the changes in the skull as well as other bones (vertebrae, long bones) which are due to abnormal function of the gonads (osteomalacia puerperalis, osteophytes during pregnancy, endostosis frontalis, osteoporosis senilis) or of the parathyroid glands (osteitis fibrosa). In none of these endocrine disorders, however, do we meet with *unilateral* i. e., *asymmetrical* changes in the bones. The asymmetry of skull and limbs appears to be the characteristic feature of the "metopic syndrome." In acro- and scaphocephaly the malformations of the fingers and toes are strictly symmetrical. Impressed with the frequent occurrence of anomalies of fingers and toes in cases with aprosopia, schistoprosopia,

cheilognathopalatoschisis, Babes (16) suggested that it is the severe types of involvement of the upper part of the face which are accompanied by malformation of the limbs. Apparently the asymmetry of face of the metopics described in Table 3 belongs to that group characterized by its tendency to abnormalities of the small bones. The integrity of the first and fifth fingers is significant, since, according to Bremer (17) and in agreement with our personal experience, there is a high incidence of deformity of the fifth fingers in the status dysrhaphicus. It is very probable that the post-central cortex exerts a definite influence upon the growth of the opposite side of the body (Penfield and Robertson, 18). In an excellent case study Gowers (19) described smallness of one hand, associated with atrophy of the corresponding area of the post-central gyrus. There is no obvious relation between the asymmetry of the extremities in our cases and the uniform cerebral hemiatrophy. Rather there exists a remote resemblance between our cases and the unilateral hyperostosis of one arm described by Léri and Joanny (20) (so-called "mélorhéostose").

Unusual and, as far as I am aware, unknown in the clinical literature on cerebral lesions, is the dissimilarity of earlobes. This dissimilarity varied in degree but was marked, upon close examination, in cases 2, 5, 6, 9, 12, 15, 16, 17, 20, 21, 22, 23, 26, 32, 33, 36, 37, 41, 46; or in 42 per cent of the cases studied. As far as length, shape and attachment of the lobule are concerned the dissimilarity does not bear the signs of dystrophy or atrophy met with in the face or the extremities in cases with cerebral lesions and usually associated with vasomotor changes. It calls to mind the difference in size and shape of the mammary glands, papillae and areolae mammae noticed by Bremer (17) in cases of status dysrhaphicus and observed in our cases 3, 4, 6, 11, 13, 14, 16, 19, 26, 35, 45, 46; or 26 per cent of the cases. In the only case of kebocephaly (Kundrat), which I had the opportunity of observing in the dissecting room, the dissimilarity of the earlobes was unmistakable. In the literature the earlobes are mostly described as flat, misshapen, and asymmetrical (Lang, 21).

The incidence of syndactylia, i. e., webbing of the proximal phalanges, mostly of 2nd and 3rd toes, was surprisingly high. It was found bilaterally in cases 1, 4, 5, 10, 12, 14, 18, 19, 22, 25, 31, 33, 35, 37, 41; or 33.3 per cent; and unilaterally in cases 24, 34, 42; or 6.6 per cent. Assuming an incidence of metopism of 6 per cent and an incidence of

syndactylia of 2 per cent, the expected coincidence would amount to only 0.12 per cent!

The persistent metopic suture along with many malformations of the small bones and of the earlobes are, in our opinion, congenital anomalies. In view of the fact that in acrocephaly the malformations are symmetrical, it is not unlikely that in the "metopic syndrome" a certain lesion of the brain, either congenital or acquired as an early age, plays a role. In our cases this assumption is substantiated to some extent by the intellectual impairment (except for cases 23, 39, 40), the occasional involvement of the oculomotor or abducens nerve, by the severe cerebral damage in group three, and by the coincidence of heterochromia of the iris, which, according to our investigations (11), is related to a certain lesion of the cervical spinal cord.

The cephalic index ranged from 52.3 (case 14) to 95.9 (case 35). In sixteen cases, or 35.6 per cent, it was less than 75, indicating dolichocephaly. Bolk in Amsterdam and Bryce in Scotland found 9.5 per cent of dolichocephalic skulls to be metopic.

The circumference ranged from 44.9 cm. (case 34) to 67.0 cm. (case 14). Close connection does not exist between size and shape of skull and metopism. The same holds true of height (chin-bregma distance), which ranged from 15.5 cm. (case 37) to 23.6 cm. (case 31). On the whole, the forehead gives the impression of being high, vaulted or prominent, and large (the type of skull that men like Kant and Leonardo showed); the temples are rather sunken, the glabella and frontal bosses smooth. In the cases with heterochromia the glabella was broad and the chin strong. In a large proportion of our patients (13 cases, or 28.8 per cent) both zygomatic processes of the frontal bone were thickened; in very few cases did the thickening involve only one zygomatic process. In view of the high incidence of rickets, this fact cannot be stressed.

In nine cases, or 20 per cent, hirsutism was encountered. The problem of hirsutism cannot be discussed in this connection. The preponderance of females (31 females : 14 males) should not be stressed, since the majority of the inmates in the school are girls or women. As far as my limited experience goes, metopism appears to be rare in colored people.

It has been noticed by some anthropologists (Martin, 23, for instance) that at the place of the original frontal suture a circumscribed area of thickening may develop (torus frontalis sagittalis). This thick-

ening would in some instances extend like a ridge upward to the bregma and down to the middle of the glabella. In that case it represents a distinguishing feature of true, classic microcephaly. As the torus sagittalis is rather the opposite of metopism, it was tempting to pay some attention to that condition. It is obvious that the torus bears a similarity to craniofacial dysostosis (Crouzon, 22). The diagnosis, however, of this latter disease requires the evidence of exophthalmos, external squint, beak-nose. Eighteen cases have been assembled and carefully studied, one of them (case 49) with the entire frontal suture bulging up to the bregma and down to the glabella, the other seventeen with the torus located precisely on the uppermost part of the frontal suture close to the hairline. It is unnecessary to dwell at length upon these cases; only in case 49 (girl, 28 years of age, moron) was there a marked webbing of the toes (2nd and 3rd) noticeable on both feet, together with signs of status dysrhaphicus (lanugo ad sacrum, deformity of both 5th fingers, heterochromia of the iris). Occasionally isodactylia, irregularity of the length of fingers, was seen. There was no tendency to asymmetry of the face or phalanges. Torus sagittalis is a condition entirely different from metopism, as it is different from microcephaly and craniofacial dysostosis. It appears to be a local peculiarity.

What distinguishes metopism and characterizes it not as a local, but as an endogenous, congenital feature, is not the occurrence of one or the other of the signs mentioned above; it is the multiplicity of bony anomalies and the asymmetrical development of a certain section of the skeleton.

SUMMARY

What is the significance of metopism? What are its salient features? What is its cause?

1. The persistent frontal suture is not to be considered as a local peculiarity of the frontal bone. It is part of the "metopic syndrome," which can be recognized upon close examination. It is possible that this syndrome will not always be fully developed, but many of the signs, particularly the trend to asymmetry, will be found in every case of metopism. The syndrome consists of anomalies of the visceral cranium and of the phalanges.

2. The thumbs and the fifth fingers are less involved than the other fingers; they are sometimes altogether free of anomalies.

3. The base of the skull is unaltered.

4. There is no connection between metopism and increased intracranial pressure, nor is metopism related to a special type of skull.

5. There is no reason to assume an endocrine origin; it is more likely that a peculiarity of the germ is responsible for metopism.

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SEX DIFFERENCES IN PUBIC HAIR DISTRIBUTION

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THE distribution of pubic hair has long been regarded as a secondary sex character. Attention has been directed especially to the upper border of the pubes; a horizontal line of termination has come to be regarded as feminine, one that is pointed towards the umbilicus as masculine. Exceptions to this rule have been stressed by Risak (1930) and Rodecurt (1934) on the basis of their observations of clinical cases. A more extensive investigation of this subject, utilizing an adequate sample of the population, therefore, is of obvious value.

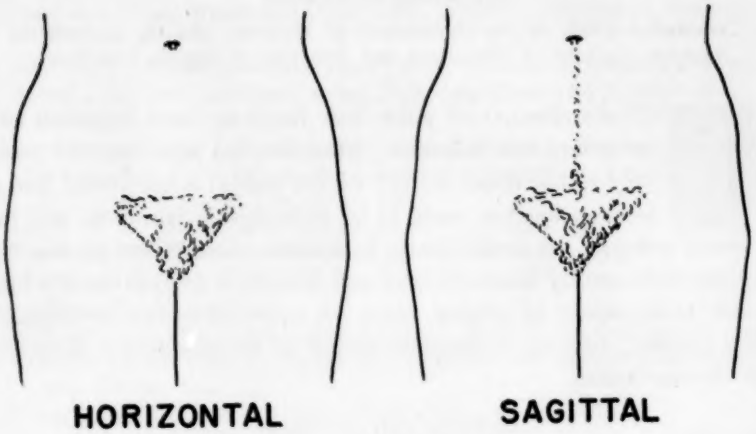
METHOD AND MATERIAL

The pubic hair pattern was studied in photographs of 1060 men and 309 women[1]. The men were of two age groups. The first was made up of 964 college students, with an average age of 18 years. The second consisted of 96 clinical subjects, ranging in age from 30 to 40 years. Two comparable groups of women included 174 college students and 53 clinical patients. Eighty-two pregnant women formed an additional series. Although all of these groups are selected, for the purpose of the present investigation they may be considered as valid samples of the general population.

Preliminary examination of this material showed that the distribution of pubic hair can be classified for practical purposes into four fundamental types, illustrated in Fig. 1. The first, or horizontal type, is characterized by terminating superiorly in a horizontal line. This corresponds to the classical "feminine" distribution. The second, or sagit-

1 The authors wish to express their appreciation for the parts of this material which were so kindly put at their disposal by Dr. H. C. Moloy of Sloane Hospital and by Dr. Harriet L. Hardy of Radcliffe College.

tal type, resembles the first except for an additional linear upward extension in the mid-line. The third, or acuminate type, corresponds to the classical "masculine" distribution, the upward extension being triangular in shape, pointing towards the umbilicus. In the fourth, or disperse type, hair is distributed over the abdomen without forming a discrete geometrical pattern.



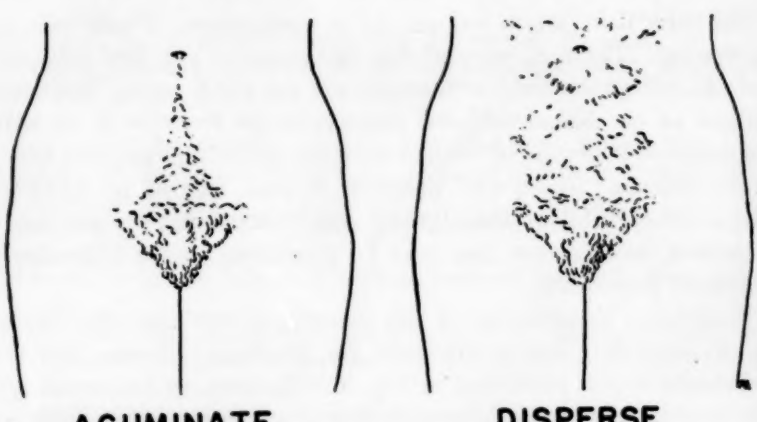


FIG. 1. FOUR FUNDAMENTAL TYPES OF PUBIC HAIR DISTRIBUTION, DETERMINED BY THE PATTERN OF UPWARD EXTENSION OF HAIR FROM THE BASIC TRIANGLE

This classification is concerned with the character of the upper border of the pubic hair. There are numerous other features, such as the luxuriance of hair development, differential distribution in the genital region and degree of extension on to the thigh, which are of interest. Their inclusion in the present study would lead to undue complication.

OBSERVATIONS

The frequency with which the various types of pubic hair distribution occurred in our series is summarized in Table 1.

In addition to the classification of pubic hair pattern, approximate quantitative estimates were made of the degree of hirsutism exhibited by the anterior aspect of the thigh and the chest. In the original observations, the amount of hair was recorded in three categories: sparse, moderate and dense. The data for the two series of males are presented in Table 2. In order to simplify the table, the moderate and dense categories have been combined into one, which is termed conspicuous. Data on thigh and chest hair were also obtained for the females, but due to their low degree of general hirsutism more extensive data would be necessary for significant correlations.

DISCUSSION

The frequency with which the horizontal type of pubic hair distribution is encountered in the college age men is surprisingly high. At this age, 38.3 per cent of the men have a horizontal pubic pattern, while 49.6 per cent have the acuminate type. Under these circumstances it is scarcely appropriate to call the horizontal pattern "feminine" and the acuminate "masculine." In the older group of men, there is a decrease in the horizontal type to 16.7 per cent, the acuminate type remaining approximately constant at 52.0 per cent. It is particularly interesting to note that in the older group the disperse pattern appears in 29.2 per cent of the cases. This pattern is characterized by general hairiness of the suprapubic region and its appearance is correlated with the general increase in hirsutism with age.

In contrast to the men, the pubic hair distribution in the women is preponderantly of the horizontal type. Only one female in ten exhibits the acuminate distribution, compared to five out of ten among the males. This frequency in the females is in fundamental agreement with the data of Rodecurt (1934).

TABLE 1

Pubic hair patterns
(Frequencies given in per cent of each group)

GROUP	HORIZONTAL	SAGITTAL	ACUMINATE	DISPERSE	NUMBER OF CASES
		Men			
18-year	38.3	12.1	49.6	0	964
30-40 years	16.7	2.1	52.0	29.2	96
		Women			
18-year	89.1	1.7	9.2	0	174
31-40 years	92.5	0	7.5	0	53
Pregnant	86.6	0	13.4	0	82

It is significant that the acuminate pattern is found as frequently in the series of pregnant women as in the other groups of females. There is consequently no indication of a correlation between fertility and pubic hair pattern. This again emphasizes the inadvisability of using the term "masculine" for the acuminate type of pubic hair distribution.

Studies on the development of pubic hair (Priesel and Wagner, 1930, and Greulich, 1942) have shown that the horizontal type appears in both sexes at puberty. It may consequently be regarded as the basic pattern from which the other types develop by upward extension. The retention of the horizontal distribution as the definitive type in most adult women seems to be a result of the general feminine characteristic of paucity of body hair rather than of a special factor affecting the pubic region.

The correlation between the upward extension of pubic hair and the development of chest and thigh hair is apparent from the data presented in Table 2. In the college series, 46 per cent of the men with sparse chest hair have a horizontal pattern of pubic hair, while only 5 per cent of the individuals with conspicuous chest hair show this pubic hair pattern. The corresponding figures for the older group are 41 per cent and 7 per cent. Of the men in the college series who have only sparse hairiness of the thigh, 79 per cent exhibit the horizontal pubic pattern, compared with 28 per cent in the men with conspicuous thigh hairiness. The older men yield corresponding figures of 48 per cent

TABLE 2

Hairiness of thigh and chest in men with different pubic hair patterns
(Frequencies given in per cent of each age group)

	THIGH HAIR SPARSE		THIGH HAIR CONSPICUOUS	
	Chest hair sparse	Chest hair conspicuous	Chest hair sparse	Chest hair conspicuous
	18 year men			
Horizontal	15.	0.	22.	1.
Sagittal	1.	0.	9.	2.
Acuminate	3.	0.	30.	17.
	30-40 year men			
Horizontal	9.	2.	3.	3.
Sagittal	0.	0.	0.	2.
Acuminate	5.	5.	11.	30.
Disperse	0.	2.	1.	27.

and 8 per cent respectively. A similar tendency for the development of pubic hair patterns other than the horizontal in hirsute individuals is evident in the female series.

General hirsutism is consequently an important, but not the only, factor determining pubic hair distribution. The tendency towards general development of hair exhibits itself earlier on the thigh than on the chest. Conspicuous thigh hair is present in 81 per cent of the college men and 77 per cent of our series of older men, but only 20 per cent of the college men had conspicuous chest hair, compared with 71 per cent in the older group.

SUMMARY

Pubic hair distribution has been examined in photographs of 1060 men and 309 women. The classical division into "masculine" and "feminine" types is found to be unsatisfactory. An adequate classification recognizes four types, designated as horizontal, sagittal, acuminate and disperse. The acuminate, or "masculine," type is present in one-half of the men and one-tenth of the women. The horizontal, or "feminine," pattern is the definitive type for nine-tenths of the women. It is also the basic type for male adolescents, is characteristic of 38 per cent of 18-year-old males, and persists in 17 per cent of the adult males.

In males the decrease in frequency of the horizontal pattern with age is associated with increase in general hirsutism and is accompanied by the development of a disperse pubic hair pattern.

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STUDIES IN THE PHYSICAL DEVELOPMENT
V.
THE OSSIFICATION TIME OF THE OS PISIFORME

BY NICHOLAS MICHELSON
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IT seems that the variability for the appearance of the ossification centers of the carpals has not been fully explored as yet on the basis of a large body of follow-up material according to race and socio-economic status. In point of fact, a different mean age at appearance is being reported by various investigators for one and the same ossification center. This can be illustrated by selecting one single carpal bone, for example, the pisiform.

According to Flory ('36) a child who is accelerated in skeletal development is more likely to become pubescent early than an individual who is retarded in bony development; and, according to the same investigator, the appearance of the pisiform occurs eight years before skeletal maturity, the appearance of the pisiform constituting a better predictor than either the ossification ratio or the total carpal area. For this reason more knowledge on the appearance of the pisiform is especially indicated.

My Negro material[1] is scanty, and the age distribution of the cases in that series is uneven; therefore I have not calculated the mean age at appearance of the pisiform for Negroes. The earliest case among Negro girls occurred at 6 years and 9 months, and no absent os pisiforme was observed at 13 years of age.

I have tabulated material obtained on economically underpriviledged white girls, followed up from 1935 to 1938 at the Mott Haven Clinic, New York City. Table 1 shows the results obtained on 180 cases.

I found the appearance of the pisiform on the roentgenogram at the age of 5 years and 9 months in the earliest case; and at 12 years of age there was no absent ossification center among the white girls.

[1] From the Harlem Hospital and the Mott Haven Clinic, New York City, N. Y.

TABLE 1

Percentages for the presence and absence of the os pisiforme according to age, white females, 180 cases

AGE	PRESENT	ABSENT
5 yrs. to 5 yrs. 9 ms.	4.55	95.45
5 yrs. 10 ms. to 6 yrs. 9 ms.	5.41	94.59
6 yrs. 10 ms. to 7 yrs. 9 ms.	21.62	78.38
7 yrs. 10 ms. to 8 yrs. 9 ms.	45.95	54.05
8 yrs. 10 ms. to 9 yrs. 9 ms.	70.27	29.73
9 yrs. 10 ms. to 10 yrs. 9 ms.	94.28	5.72
10 yrs. 10 ms. to 11 yrs. 9 ms.	96.55	3.45
11 yrs. 10 ms. to 12 yrs. 9 ms.	100.00	0

The actual time of appearance of the pisiform was calculated from consecutive plates taken about one year apart, on the same child. Straight line interpolation was used to determine the actual time of appearance. The first plate did not show the pisiform, and the second did. Twenty-one white girls showed the observed appearance of the pisiform, and the mean of these cases is 8 years and 7 months.

Baldwin *et al.* ('28) stated that for white girls ossification was first found "at 7 years" and that all white girls showed ossification of the pisiform at 12 years. Baldwin's material was obtained from a "good class." Thus we see that the poor white population studied recently, shows about the same tempo of calcification of the pisiform as the economically better-to-do Iowa children had shown prior to the year 1928.

It seems that the calculation of the variability of the time of ossification of the pisiform can only serve a useful purpose when we con-

sider it as a standard for one and the same type of population or, in a stricter sense, for a given series under study.

In comparing my findings with, for example, those of Flory ('36) we note that he, too, found the presence of the pisiform among all the white girls at 12 years of age. However, the percentages show that the age of appearance of the pisiform is decidedly earlier in my series.

I have applied the normal probability curve[2] to my material, to Flory's material and, finally, to his and my data treated together. The results obtained are shown in Table 2.

TABLE 2

Mean age and standard deviation for the appearance of the os pisiforme, white girls

MICHELSON	FLORY	MICHELSON AND FLORY COMBINED
8 years 6 months ± 1 year 5 months	9 years ± 1 year 3 months	8 years 9 months ± 1 year 3 months

SUMMARY

The mean age at appearance of the os pisiforme among economically underprivileged white girls who were observed from 1935 to 1938 in New York City, was 8 years 6 months ± 1 year 5 months.

[2] The technical procedure of applying the normal probability curve consists of plotting the percentages on probability paper and fitting a straight line to the points expressing the trend. On the 50% line the mean age is read off, on the 84% line the age one standard deviation above the mean, and on the 16% line the age one standard deviation below the mean. In subtracting the mean age from the age one standard deviation above it, or by subtracting from the mean age the age one standard deviation below it, the standard deviation for the entire frequency distribution is obtained.

The mathematical basis for this procedure is explained in a publication by Palmer, Klein and Kramer ('38) who determined by the application of the normal probability curve the mean age and standard deviation for the eruption of permanent teeth; and it is noteworthy that their results resemble those obtained by Hellman ('43) who derived his data from follow-up material and calculated the mean age and standard deviation by the traditional statistical method.

The above described method of applying the normal probability curve yields valid results only when dealing with a normal frequency distribution.

The presence of the pisiform was 100 per cent at 12 years of age. However, the percentages show the age of appearance of the pisiform as earlier in the present series than in the populations studied by previous observers. This may be interpreted as a sign of accelerated physical development in the recent series.

By applying the normal probability curve to my material combined with that of Flory, there was obtained for white girls the following mean age and standard deviation for the appearance of the os pisiforme: 8 years 9 months ± 1 year 3 months.

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STUDIES IN THE PHYSICAL DEVELOPMENT
VI. THE CHRONOLOGY OF PHYSIOLOGIC EVENTS

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THE rapid increase of the variability in physiologic events from the period of pregnancy up to death was pointed out by Boas ('35, '40). The aim of this paper is to present the chronology and variability of physiologic events in terms of years. While it was intended to cover the entire life cycle, the data had to be selected from the point of view of important land-marks occurring between birth and the time of senile decay. Since only statistically valid material could be considered herein, some of the consecutive phases of growth and aging could be shown for merely one sex. In general, the list of items compiled in this investigation discloses many a gap which must be accounted for by future research.

The scanty data which are available for the American Negro were included in the table.

SUMMARY

The chronology of physiologic events and their variabilities in terms of years are presented. While listing the consecutive phases for the period between birth and death, the few available comparable data for the American Negro were also cited.

TABLE 1

Chronology and variability[1] of physiologic events in years

	FEATURES	MEAN AGE	VARIABILITY
1	Period of gestation (from Anderson *et al.* '43)	0.0	± 0.6
2	Appearance of the os capitate, girls (Pyle *et al.* '43)	0.19	± 0.17
3	Appearance of the os capitate, boys (Pyle *et al.* '43)	0.2	± 0.15
4a	Eruption of deciduous upper lateral incisors, boys (Boas '27)[2]	1.33	± 0.28
5a	Eruption of deciduous upper lateral incisors, girls (Boas '23)	1.4	± 0.37

TABLE 1

Chronology and variability[1] of physiologic events in years

	FEATURES	MEAN AGE	VARIABILITY
4b	Eruption of deciduous upper lateral incisors, boys (Rabinow '42)[2]	0.87	± 0.2
5b	Eruption of deciduous upper lateral incisors, girls (Rabinow '42)	0.99	± 0.23
6	Total deciduous dentition, boys (Doering and Allen '42)	2.33	± 0.36
7	Total deciduous dentition, girls (Doering and Allen '42)	2.25	± 0.33
8	Eruption of left permanent lower central incisor, boys (Hellman '43)	6.29	± 0.77
9	Eruption of left permanent lower central incisor, girls (Hellman '43)	6.29	± 0.88
10	Appearance of os pisiforme, white girls (Author)	8.5	± 1.42
11	Maximum rate of growth, girls (Boas '40; standard variability)	12.0	± 1.2
12	Appearance of pubic hair, boys (Boas '40; value of probable variability)	12.7	± 1.60
13	Eruption of left upper second molar, girls (Hellman '43)	12.86	± 1.67
14	Puberty, white girls (Author '44)	13.0	± 1.04
15	Eruption of left upper second molar, boys (Hellman '43)	13.03	± 1.59
16	Puberty, Negro girls (Author '44)	13.4	± 1.2
17	Maximum rate of growth, boys (Boas '40; standard variability)	14.4	± 1.1
18	Eruption of left lower third molar, females (Hellman '43)	20.09	± 2.52
19	Eruption of left lower third molar, males (Hellman '43)	20.34	± 2.63
20	Appearance of grey hair, white males (Boas and Michelson '32)	34.2	± 8.6
21	Calcification of first costal cartilage 60%, males (Boas '40)[3]	36.0	± 8.6
22	Calcification of first costal cartilage 60%, females (Boas '40)	38.0	± 8.6
23	Appearance of grey hair, Negro males (Boas and Michelson '32)	43.9	± 10.3
24	Menopause (Boas '40; standard variability)	44.5	± 3.9
25	Death due to arteriosclerosis, males (Steinhaus '32)	64.0	± 5.5
26	Death due to arteriosclerosis, females (Steinhaus '32)[4]	64.0	± 5.47

[1] The variabilities listed in Table 1 are expressed as standard deviations, unless stated otherwise. When an item is given together with the note "the value of the probable variability," one-half of the cases falls within the period limited by the average, minus and plus the amount which expresses the variability. When the term "standard variability" is mentioned, the variability is expressed as the mean square deviation from the average age. (Boas '40) gave for the gestation period the following figures: standard deviation: .06, the value of the probable variability: .09, and the standard variability: .04.

[2] It will be noticed that there is a striking difference between the data of Boas and Rabinow for the deciduous dentition. Boas obtained his material from a poverty-stricken population (Boas '23, '27) and noted the developmental retardation in that series.

[3] The variability for the calcification of the first costal cartilage was calculated by Boas from the material presented by Michelson ('34).

[4] Boas ('40) obtained in males for death due to arterial diseases the average age of 62.5 years ± 8.80 (value of the probable variability). He also stated that death by arteriosclerosis had a variability exceeding seven years. However, in a private communication he expressed dissatisfaction with the type of source material available at the time when these calculations were made.

There is a need for new data to be established in the light of research which must define the concept "Death due to arterial diseases" in strict scientific terms; and the average age and variability for death caused by arteriosclerosis must be itemized as due to sclerosis of the coronary arteries or other arteries.

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RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Lowell J. Reed, Editor of Human Biology, 615 North Wolfe Street, Baltimore - 5, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

1. *Evolution—General Principles*

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4. *Population*

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